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TESTING MATERIALS

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PROCEEDINGS
OF THE
TWENTY-FIFTH ANNUAL MEETING

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NEW AND REVISED TENTATIVE STANDARDS

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SUMMARY OF THE PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL MEETING.

ATLANTIC CITY, N. J., JUNE 27–30, 1922.

THE TWENTY-FIFTH ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at the Chalfonte-Haddon Hall, Atlantic City, N. J., June 27–30, 1922. The following is an analysis of the attendance at the meeting: Members in attendance or represented, 626; guests, 116; total, 742; ladies, 172. The corresponding statistics for the Twenty-fourth Annual Meeting are: Members in attendance or represented, 583; guests, 116; total, 699; ladies, 131.

FIRST SESSION—TUESDAY, JUNE 27, 9.30 A. M.

On Non-Ferrous Metals and Corrosion.

President C. D. Young in the chair.

The minutes of the Twenty-fourth Annual Meeting were approved as printed.

The President appointed F. M. Waring and R. E. Hess as tellers to canvass the vote for officers.

The report of Committee B-1 on Copper Wire was, in the absence of the chairman, J. A. Capp, presented by W. H. Bassett. The announcement of the committee that, in view of cooperative work recently started with the American Electric Railway Association, which may lead to the preparation of separate specifications for trolley wire, the committee desires at the next annual meeting to remove all the requirements specifically covering trolley wire from the Standard Specifications for Hard-Drawn Copper Wire (B 1 – 15), was received. It was voted to publish the proposed revisions of the specifications as tentative for a year in anticipation of the formal request of the committee next year that the modifications actually be made and the specifications as thus revised continued as the standard for round hard-drawn copper wire. The report of the committee was, on motion, adopted.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by its Vice-Chairman, W. H. Bassett, in the absence of the chairman, William Campbell. The following actions were taken on the recommendations of the committee:

The Tentative Specifications for Pig Lead (B 29 - 20 T), with revisions recommended in the report of the committee, were continued as tentative.

The Tentative Specifications for Nickel (B 39 - 21 T) were referred to letter ballot of the Society for adoption as standard, with the inclusion of the following explanatory footnote recommended by the committee in presenting the report:

> "The requirement for carbon in electrolytic nickel covers both contained and mechanically attached carbon from the starting sheet and it should be recognized that while lower values can be obtained by separating the cathode sheets from the starting sheet and pickling before drilling, this method of taking the sample is outside of the specifications."

The proposed Tentative Specifications for Brass Pipe, Standard Sizes; for Copper Pipe, Standard Sizes; and for Seamless Admiralty Condenser Tubes and Ferrule Stock were accepted for publication as tentative standards. A slight modification of the section on strain test in the Specifications for Brass Pipe and for Condenser Tubes, designed to clarify the meaning, was offered by the committee and accepted.

The Tentative Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings (B 30 - 21 T), revised as recommended in the report of the committee, were referred to letter ballot of the Society for adoption as standard.

The proposed Tentative Methods of Chemical Analysis of Bronze Bearing Metal and of Chemical Analysis of Brass Ingots and Sand Castings were accepted for publication as tentative standards.

The Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (B 24 - 20 T), with revisions recommended in the report of the committee, were continued as tentative.

Upon invitation of the chair, John R. Freeman, Jr., presented the data in the appendix to the committee's report on "The Physical Properties of the A.S.T.M. Tentative Standard White Metal Bearing Alloys."

On motion of Mr. Bassett the report of Committee B-2, as amended, was adopted. The recommendation that the list of non-ferrous alloys submitted two years ago by the committee be published was referred to Committee E-6 on Papers and Publications.[1]

A paper on "Physical Properties of Some Copper-Silicon-Aluminum Alloys when Sand Cast," by E. H. Dix, Jr., and A. J. Lyon, was presented by P. D. Merica in the absence of the authors.

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[1] The list of alloys referred to was accepted by Committee E-6 for publication and appears as Appendix III to the Report of Committee B-2 on Non-Ferrous Metals and Alloys. See p. 213.—ED.

The report of Committee A-5 on Corrosion of Iron and Steel was then presented by the acting chairman, J. H. Gibboney, and adopted.

A paper by W. D. Bancroft entitled "Preliminary Notes on Corrosion" was, in the author's absence, presented by W. M. Corse. This paper introduced a discussion on the topic "Corrosion" which was participated in by a number of members.

A paper entitled "A Method for Determining the Spelter Coating on Iron and Steel Sheets by Measuring the Rise in Temperature of the Acid Employed," by D. M. Strickland, was presented by the author and discussed.

The tellers on the vote for election of officers presented their report, and in accordance therewith the President announced the election of the following officers:

For President, to serve for one year: G. K. Burgess.

For Vice-President, to serve for two years: W. H. Walker.

For Members of Executive Committee, to serve for two years: D. M. Buck, W. M. Corse, W. K. Hatt, J. R. Onderdonk.

The President requested Past-Presidents A. A. Stevenson and G. H. Clamer to escort the President-elect to the chair. Doctor Burgess expressed his appreciation of the honor conferred upon him by his election to the Presidency of the Society, and in pledging his endeavor to uphold the ideals of the Society suggested as a program for the coming year the desirability of making our standards more generally applicable and mentioned three opportunities that lie before us: the adoption of our standards as American Standards by submission to the American Engineering Standards Committee, the extension of the use of our standards for export trade, and by making our standards available for the use of the Government, which has recently organized a Federal Specifications Board for the purpose of unifying specifications for government purchases.

The Vice-President-elect, at the request of the President, addressed the meeting and expressed his appreciation of the honor of being elected to the Vice-Presidency of the Society.

The meeting then adjourned till 3 P. M.

SECOND SESSION—TUESDAY, JUNE 27, 3 P. M.

On Wrought, Cast and Malleable Iron.

Vice-President G. K. Burgess in the chair.

The report of Committee A-2 on Wrought Iron was presented by its chairman, H. E. Smith. The revisions in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 21) recommended by the committee were accepted for publication as tentative. The revisions recommended by the committee in the Standard Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 – 18) were accepted for publication as tentative.

The revisions in the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 21 T), affecting requirements for iron boiler tubes only, as recommended in the report of the committee, were accepted and the specifications as thus revised continued as tentative.

On motion, the report of the committee was adopted.

A paper on "Merchant Bar Iron Made by the Busheled Scrap Process," by W. M. Myers, was, in the absence of the author, presented by H. E. Smith.

A paper by Henry S. Rawdon and Samuel Epstein entitled "Some Observations of the 'Nick-Bend' Test for Wrought Iron," was presented by Mr. Rawdon and discussed.

A paper by William R. Webster on "The Physics of Cast Iron and Its Bearing on All Cast-Iron Products and Specifications for Cast Iron" was presented by Richard Moldenke in the absence of the author. The discussion of this paper was deferred until the presentation of the revised Specifications for Foundry Pig Iron by Committee A-3 on Cast Iron.

The report of Committee A-3 on Cast Iron was then presented by its chairman, Richard Moldenke. The proposed revised Tentative Specifications for Chilled Cast-Iron Wheels were accepted for publication as tentative with certain modifications proposed by the committee in presenting its report, as follows:

Section 2 (a).—Change the sulfur requirement from 0.17 to 0.18 per cent.

Section 2 (c).—Omit this section, reading as follows:

> "It is desired that the phosphorus content shall not exceed 0.30 per cent."

Section 15.—Change the note following Section 15 of the specifications, from its present form: namely,

> "The chill and physical tests specified only cover 33-in. wheels of the weights listed; other diameters and weights shall be in proportion,"

to read as follows:

> "The chill and physical tests specified only cover 33-in. wheels of the weights listed. Requirements for wheels of other sizes are to be supplied by the committee."

The committee submitted with its report proposed Tentative Specifications for Foundry Pig Iron designed to supersede when adopted the present standard specifications for that product. There was an extended discussion of these specifications in conjunction with the paper by Mr. Webster, the discussion having principally to do with the question of whether the specifications are intended to include pig iron for use in malleable iron and steel foundry practice as well as gray-iron foundry practice. Mr. Moldenke moved that the proposed specifications be accepted for publication as tentative. A division being called for, the vote was recorded as 25 affirmative, 8 negative. The Chair declared the specifications accepted for publication as tentative.

The proposed Tentative Specifications for High-Test Gray-Iron Castings were accepted for publication as a tentative standard.

On motion, the report of the committee as amended was adopted.

The report of Committee A-7 on Malleable Castings was presented by its chairman, H. E. Diller. The proposed revisions of the Standard Specifications for Malleable Castings (A 47 - 19) were accepted for publication as tentative, and the report was adopted.

The meeting then adjourned till 8.30 P. M.

THIRD SESSION—TUESDAY, JUNE 27, 8.30 P. M.

Presidential Address and Reports of Administrative Committees.

Past-President A. A. Stevenson in the chair.

The Chair stated it was his sad duty to make formal announcement of the recent death of two Past-Presidents of the Society, Henry M. Howe and Alfred W. Gibbs, of which the members had previously been advised; and of the death of its Past-Vice-President S. S. Voorhees. The following resolutions adopted by the Executive Committee on the death of these past officers were read by the Secretary-Treasurer, following which the meeting rose in silent memory:

HENRY MARION HOWE

1848–1922.

The American Society for Testing Materials in annual meeting assembled desires to record its profound sorrow in the death on May 14, 1922, of its honored Past-President and Honorary Member, Henry Marion Howe.

Foremost among the metallurgists of the world, renowned as an investigator and teacher, noted for his keen spirit of scientific research and unusual ability to interpret new discoveries and to formulate theories that would explain and correlate the facts that he and others had developed, and gifted with the power to clothe his ideas in a language that all could understand, Henry Marion Howe attained an eminence in the scientific and technical world that is reached by but few men.

It was only natural that honors should come to this man. Universities, scientific bodies and governmental agencies the world over honored him for his notable achievements. In our field of testing the materials of engineering, he was a leader. He was interested from its very inception in the activities of the Society and contributed greatly to its development and progress. As Vice-Chairman of the American Section of the International Association for Testing Materials in 1898–1900 and Chairman in 1900–1902, his leadership in those days in our history of doubt and uncertainty was instrumental in laying the foundations upon which our Society has grown. As President in 1910–1912, he again was called to the highest office in the Society. He was honored by the Presidency of the International Association for Testing Materials in 1910, and in 1919 he was made an Honorary Member of our Society. He contributed many papers and discussions at our annual meetings and rendered important service on our committees, notably that on Heat Treatment of Iron and Steel. In every way the Society has benefited and been honored by his membership.

His death brings a deep sense of personal loss to all who were privileged to know him and appreciate the broad humanness of his character. The Society mourns the loss of so distinguished and honored a member and extends its heartfelt sympathy to his family.

ALFRED W. GIBBS

1856–1922.

The American Society for Testing Materials in annual meeting assembled wishes to place on record its great loss in the death of its esteemed Past-President, Alfred W. Gibbs, on May 19, 1922.

A member of the Society since its incorporation in 1902, Mr. Gibbs took an active interest in Society affairs. He was associated with railroad work continously from 1878, when he graduated from Stevens Institute of Technology, till his death. He rose high in his chosen profession, having been Chief Mechanical Engineer of the Pennsylvania System for the past eleven years. From his wealth of experience in this field he contributed much of value to the committee work of the Society, notably in the discussion of specifications for steel for tank cars, upon which he was probably the leading authority in this country, and in the activities of our committees on Cast Iron and Coal. For a period of six years he served ably in the executive councils of the Society—as Vice-President in 1912–14, as President in 1914–15, and for the next three years as Past-President. A notable service in recent years, which extended to the day of his death and which kept him in close touch with Society affairs, was his work as one of the Society's representatives on the American Engineering Standards Committee, where his knowledge of railway standardization work and his ability and sound judgment were of inestimable value to our Society

The rugged simplicity and honesty of his character and the charm and kindliness of his nature endeared him to all who knew him. We of the Society mourn the loss of so worthy a member and extend our heartfelt sympathy to his family.

SAMUEL STOCKTON VOORHEES

1867–1921.

The Executive Committee of the American Society for Testing Materials learns with profound sorrow of the death, on September 23, 1921, of one of the most active and beloved members of the Society, Samuel Stockton Voorhees. A member since the Society was incorporated in 1902, he served in many capacities; for ten years as chairman of the Committee on Preservative Coatings, and from 1914 as chairman of the Committee on Corrosion of Iron and Steel. He was a member of the Executive Committee from 1914 to 1916 and Vice-President of the Society from 1916 to 1918. During the entire period of his Society activities he was in the service of the Government in various capacities as engineer and chemist, where he has left a notable record of achievement.

His loyal service to the Society and the charm and kindliness of his personality have left a deep and lasting imprint upon the work of the American Society for Testing Materials.

Resolved, that this Minute be recorded in the Minutes of the Executive Committee, and that copies be transmitted to Mrs. Voorhees and the U. S. Bureau of Standards.

The Chair then introduced President C. D. Young, who presented the annual Presidential Address entitled "A Quarter Century of Progress."

The Secretary-Treasurer presented the annual report of the Executive Committee. The proposed revision of Article VI, Section 1, of the By-laws consisting of the omission of the words "Standard Tests" in the first sentence of Section 1: namely,

> "The term 'Standards' shall be applied collectively to standard specifications, [standard tests,] standard methods and standard definitions,"

was referred to letter ballot vote of the membership.

On motion, the report of the Executive Committee was adopted.

The report of Committee E-5 on Standing Committees was presented by its chairman, C. L. Warwick, and adopted.

The report of Committee E-6 on Papers and Publications was presented by its chairman, C. L. Warwick, and adopted.

The meeting then adjourned till the following morning, and was followed by an informal dance and smoker.

FOURTH SESSION, WEDNESDAY, JUNE 28, 9.30 A. M.

On Steel.

Vice-President Guilliaem Aertsen in the chair.

The report of Committee A-1 on Steel was presented by F. M. Waring, chairman. Because of the lack of agreement that developed in the committee regarding the advisability of submitting certain revisions in tables of permissible variations and over-weights of plates, the committee withdrew the proposed revisions in its report as preprinted covering the following standards and tentative standards:

Standard Specifications for:

Structural Steel for Bridges (A 7 - 21);
Structural Nickel Steel (A 8 - 21);
Structural Steel for Buildings (A 9 - 21);
Structural Steel for Locomotives (A 10 - 21);
Structural Steel for Cars (A 11 - 21);
Boiler and Firebox Steel for Locomotives (A 30 - 21).

Tentative Specifications for:

Boiler and Firebox Steel for Stationary Service (A 70 - 21 T);
Steel Plates for Forge Welding (A 78 - 21 T).

The proposed revisions of the following standard specifications were accepted for publication as tentative:

Steel Track Spikes (A 65 - 18);
Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 - 21);
Welded and Seamless Steel Pipe (A 53 - 21);
Automobile Carbon and Alloy Steels (A 29 - 21).

In the latter specification, a correction in Table I changing the desired percentage of carbon, fourth line, from 0.45 to 0.46 per cent, was made.

The proposed Tentative Methods of Chemical Analysis of Plain Carbon Steel and of Chemical Analysis of Alloy Steels were accepted for publication as tentative standards, with the understanding that when adopted as standard they will supersede the present standard methods of the same titles.

The chairman stated that the ladle test ingot investigation mentioned in the report has since been completed and copies of the report will be sent to the members of the committee for consideration at the next meeting.

The chairman then summarized briefly the joint activities of the committee with a committee of the American Railway Association which had resulted in the preparation of proposed Tentative Specifications for Carbon-Steel Castings for Railroads. These specifications were discussed jointly with the paper by Lawford H. Fry entitled "Tensile Properties of Steel Castings," which was then presented by the author. Following the discussion, the proposed tentative specifications were accepted for publication as a tentative standard, and the report of Committee A-1, as amended, was adopted.

The preliminary report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel on "Effect of Sulfur on Rivet Steel" was presented by the chairman of the Joint Committee, G. K. Burgess, and discussed.

The report of Committee A-4 on Heat Treatment of Iron and Steel was presented by the secretary, J. H. Hall, in the absence of the chairman, H. M. Boylston. The proposed Recommended Practice for Heat Treatment of Carbon-Steel Castings was accepted for publication as a tentative standard, with the understanding that when adopted as standard it would supersede the present Recommended Practice for Annealing of Carbon-Steel Castings (A 36 – 14).

A paper by T. Spooner and I. F. Kinnard on "Electrical and Magnetic Weld Testing as Applied to Butt-Welded Steel Plates" was presented by Mr. Spooner.

The meeting then adjourned till 8 P. M.

FIFTH SESSION—WEDNESDAY, JUNE 28, 8 P. M.

Symposium on Impact Testing of Materials.

President C. D. Young in the chair.

The chair called on T. D. Lynch, chairman of the special committee that had developed the Symposium, to introduce the discussion. Following Mr. Lynch's remarks, H. L. Whittemore presented a "Resumé of Impact Testing of Materials, with Bibliography." This was followed by a discussion of the subject "Machines and Test Specimens Used in Impact Testing," introduced by the following papers which were presented by their authors:

"Impact Tests of Metals," by D. J. McAdam, Jr.;
"Impact Tests of Wood," by Thomas R. C. Wilson;
"Impact Tests of Road Materials," by Earl B. Smith.

The subject of "Standardization of Machines and Specimens for

Notched Bar Impact Tests of Metals" was discussed in the following two papers presented by their authors:

"Resumé of American Practice in Notched Bar Impact Tests of Metals," by C. L. Warwick.

"A Review of the Work on Impact Testing done by the British Engineering Standards Association," by T. D. Lynch.

A discussion on "The Measurement of Impact" was introduced by the following papers:

"Measurement of Pressures Caused by Impact," by C. E. Margerum, presented by C. L. Warwick.

"Measuring Forces in Impact," by Armin Elmendorf, presented by T. R. C. Wilson.

"Measurement of the Force of Impact by Means of the Elastic Stretch of a Steel Bar," by H. F. Moore, presented by the author.

A paper by F. C. Langenberg and N. Richardson on the "Significance of the Impact Test" was then presented by Mr. Langenberg, following which was a general discussion of the entire subject.

The meeting then adjourned till the following morning.

SIXTH SESSION—THURSDAY, JUNE 29, 9.30 A. M.

On Fatigue of Metals, Methods of Testing and Nomenclature.

Past-President G. H. Clamer in the chair.

A paper by H. F. Moore, J. B. Kommers and T. M. Jasper entitled "Fatigue or Progressive Failure of Metals under Repeated Stress" was presented by Mr. Moore in conjunction with an exhibit of certain of the fatigue testing machines that were developed in the Joint Investigation of the Fatigue of Metals under the auspices of the National Research Council, Engineering Foundation, the General Electric Co. and the Engineering Experiment Station of the University of Illinois. The paper was extensively discussed, the discussion being closed by Mr. Jasper.

A paper by Fred E. Foss and R. C. Brumfield on "Some Measurements of the Shape of Brinell Ball Indentation," was, in the absence of the authors, presented by title, following a brief explanatory statement by A. E. Bellis, chairman of the National Research Council Committee on Hardness Testing of Metals.

The report of Committee E-1 on Methods of Testing was, in the absence of the chairman, J. A. Capp, presented by the vice-chairman, H. F. Moore. After discussion, the report was adopted, including the recommendation that the Suggested Definitions Relating to Methods of Testing and the Suggested Methods for Verification of Testing Machines be published in the Proceedings for information.

The report of Committee C-5 on Fireproofing was presented by its chairman, Ira H. Woolson. Proposed revisions in the Standard Specifications for Fire Tests of Materials and Construction (C 19 – 18), with certain corrections that had been adopted subsequent to the preprinting of the committee's report, were accepted for publication as tentative.

The committee also recommended that in view of the fact that the Standard Specifications for Fire Tests of Materials and Construction had been approved as "Tentative American Standard" by the American Engineering Standards Committee, the Executive Committee of the Society present these suggested amendments to the Standards Committee for consideration, with the request that the American Society for Testing Materials be appointed as the sponsor body for the purpose of coordinating all interests in this subject and for further developing these amendments. On motion, this recommendation was referred to the Executive Committee, and the report of the committee, as amended, was adopted.

W. H. Fulweiler, chairman of Committee D-15 on Thermometers, then stated for the committee that inasmuch as it had been found impossible to include at this time essential data required to be inserted in the three proposed tentative specifications for partial immersion thermometers appended to its preprinted report, the committee had determined to withdraw its proposed report.

The report of Committee E-8 on Nomenclature and Definitions was presented by its chairman, Cloyd M. Chapman, and on motion was adopted.

The meeting then adjourned till 3 P. M.

SEVENTH SESSION—THURSDAY, JUNE 29, 3 P. M.

On Coal, Coke, Timber and Shipping Containers.

Vice-President Guilliaem Aertsen in the chair.

The report of Committee D-5 on Coal was presented by its chairman, A. C. Fieldner. In view of the further work that is planned in the study of fusibility of coal ash, the recommendation of the committee that the Tentative Method of Test for Fusibility of Coal Ash (D 22 – 19 T) be continued as tentative, with minor revisions as outlined in the committee's report, was approved. The proposed revisions of the Standard Methods for Laboratory Sampling and Analysis of Coal (D 22 – 21) were accepted for publication as tentative.

The proposed Tentative Definitions of Terms Relating to Coal were accepted for publication as a tentative standard.

The chairman announced certain slight amendments in the wording of the report, and the report as thus amended was, on motion, adopted.

The following papers were then presented by their respective authors:

"Forms of Specifications for Purchasing Coal," by Hubb Bell.

"A Rational Basis for Coal Purchase Specifications," by E. B. Ricketts.

Following the presentation of these papers, a discussion on "Specifications for Coal" was formally opened by O. P. Hood and W. D. Barrington.

The report of Committee D-6 on Coke was presented by its secretary, A. C. Fieldner, in the absence of the chairman, Richard Moldenke. The proposed Tentative Method of Shatter Test for Coke was accepted for publication as a tentative standard.

The proposed revisions of the Standard Methods of Laboratory Sampling and Analysis of Coke (D 37 – 21) were accepted for publication as tentative.

On motion, the report of the committee was adopted.

Mr. Fieldner then announced on behalf of Committees D-5 on Coal and D-6 on Coke that at their respective meetings held during the annual meeting resolutions had been adopted recommending to the Executive Committee that the two committees be consolidated into one committee in consideration of the fact that the subjects under their consideration are closely allied and that the membership of the two committees is largely the same.

The report of Committee D-7 on Timber was presented in the absence of the chairman, Hermann von Schrenk, by T. R. C. Wilson. The proposed Tentative Methods of Testing Small Clear Specimens of Timber were accepted for publication as a tentative standard and the report of the committee was adopted.

The report of Committee D-10 on Shipping Containers was presented by its secretary, T. R. C. Wilson, in the absence of the chairman, J. A. Newlin. The Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction (D 68 – 20 T) were continued as tentative in the proposed revised form as indicated in the report of the committee. The report of the committee was then adopted.

The meeting then adjourned till 8 P. M.

EIGHTH SESSION—THURSDAY, JUNE 29, 8 P. M.

On Concrete Aggregates, Road Materials and Waterproofing.

(Held simultaneously with the Ninth Session.)

Past-President G. S. Webster in the chair.

A paper by R. W. Crum on "The Use of Excess Sand and Pit-Run Gravel in Concrete Pavements" was presented by the author and discussed.

The report of Committee C-9 on Concrete and Concrete Aggregates, A. T. Goldbeck, chairman, was presented by the secretary, J. C. Pearson. The proposed Tentative Method of Decantation Test for Sand and Other Fine Aggregates was accepted for publication as a tentative standard.

The following tentative standards were referred to letter ballot of the Society for adoption as standard:

Tentative Method of Test for Voids in Fine Aggregate for Concrete (C 30 – 20 T);
Tentative Method of Test for Organic Impurities in Sands for Concrete (C 40 – 21 T);
Tentative Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 – 21 T).

On motion, the report of the committee was adopted.

The following papers were then presented by their respective authors and discussed:

"Physical Properties of Subgrade Materials," by J. R. Boyd.
"An Impact Test for Gravel," by F. H. Jackson.

The report of Committee D-4 on Road and Paving Materials was presented in the absence of the chairman, A. H. Blanchard, by C. N. Forrest. The following action was taken on the recommendations of the committee:

The proposed revision in the Standard Method of Test for Softening Point of Bituminous Materials Other Than Tar Products (Ring-and-Ball Method) (D 36 – 21) correcting an error which was discovered in the description of the apparatus, was referred to letter ballot of the Society.

The Tentative Specifications for Block for Granite Block Pavements (D 59 – 19 T), amended as recommended in the report of the committee, were referred to letter ballot of the Society for adoption as standard.

The Tentative Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including some

Material Survey Methods (D 75 - 20 T) were referred to letter ballot of the Society for adoption as standard.

The committee reported that it had concurred with Committee C-9 in the above-mentioned recommendation that the proposed Tentative Method of Decantation Test for Sand and Other Fine Aggregates be published as tentative, with the understanding that when adopted as standard it will supersede the present Standard Method of Test for Quantity of Clay and Silt in Sand for Highway Construction (D 74 - 21).

The recommendation of the committee that the present Tentative Specifications for Workability of Concrete for Concrete Pavements (D 62 - 20 T) be withdrawn and replaced by the proposed Tentative Method of Test for Consistency of Portland-Cement Concrete for Pavements or for Pavement Base, was approved and the latter Method accepted for publication as a tentative standard.

The following tentative standards, with revisions recommended in the report of the committee, were continued as tentative:

Tentative Specifications for:

Coal-Tar Pitch for Block Filler (D 112 - 21 T);
Calcium Chloride for Dust Prevention (D 98 - 21 T);
Asphalt Cement, 40 to 50 Penetration (D 99 - 21 T);
Asphalt Cement, 50 to 60 Penetration (D 100 - 21 T);
Asphalt Cement, 60 to 70 Penetration (D 101 - 21 T);
Asphalt Cement, 70 to 90 Penetration (D 102 - 21 T);
Asphalt Cement, 90 to 120 Penetration (D 103 - 21 T).

Tentative Method:

Of Test for Ductility of Bituminous Materials (D 113 - 21 T).

The following proposed tentative specifications and methods were accepted for publication as tentative standards:

Specifications for:

Block for Recut Granite Block Pavements.
Block for Durax Granite Pavements.
Asphalt Cement, 120 to 150 Penetration, for Use in Asphalt Macadam Pavements.
Asphalt Cement, 10 to 15 Penetration, for the Manufacture of Asphalt Block.
Asphalt Cement, 15 to 25 Penetration, for the Manufacture of Asphalt Block.

Methods of:

Mechanical Analysis of Subgrade Soils, with the correction recommended by the committee that the word "ultra-clay" be changed to "suspension" clay in all cases.

Float Test for Bituminous Road Materials, with the correction of certain typographical errors and the addition of certain essential dimensions in the illustration of the apparatus.

Sampling Bituminous Materials.

On motion, the report of the committee as amended was adopted.

The report of Committee D-8 on Waterproofing Materials was presented by C. N. Forrest, vice-chairman. The proposed Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing below Ground Level and for Asphalt for Use in Damp-proofing and Waterproofing above Ground Level were accepted for publication as tentative standards, to supersede the present Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing (D 40 – 17 T). Likewise, the proposed Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing below Ground Level and for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing above Ground Level were accepted for publication as tentative standards, to supersede the present Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing (D 42 – 17 T).

The Tentative Specifications for Primer for Use with Asphalt for Use in Damp-proofing and Waterproofing (D 41 – 17 T) and for Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing (D 43 – 17 T), with revisions recommended in the report of the committee, were continued as tentative.

The proposed Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing, with certain minor modifications and a rearrangement of Section 16, were accepted for publication as a tentative standard.

The proposed Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures were accepted for publication as a tentative standard.

The proposed Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums was accepted for publication as a tentative standard, with the following correction recommended by the committee in presenting the report:

Section 3. Change from its present form: namely,

"By means of an augur, or brace and ¾-in. bit, or other suitable means, a ¼ to ½-lb. sample shall be removed from the top, bottom and center of each package selected, care being taken to avoid contamination with superficial water, wooden slivers, or other foreign matter."

to read as follows:

"By means of an augur, or brace and $\frac{3}{4}$-in. bit, or other suitable means, a $\frac{1}{4}$ to $\frac{1}{2}$-lb. sample shall be removed from the center and from two points at least 3 in. from the top, bottom and side of each package selected, care being taken to avoid contamination with superficial water, wooden slivers, or other foreign matter."

Mr. Forrest stated that the committee would confer during the year with Committee D-4 on Road and Paving Materials for the purpose of harmonizing the methods of sampling bituminous materials that had been proposed separately by the two committees at this annual meeting.

On motion, the report as amended was adopted.

The meeting then adjourned till the following morning.

NINTH SESSION—THURSDAY, JUNE 29, 8 P. M.

On Preservative Coatings.

(Held simultaneously with the Eighth Session.)

Gustave W. Thompson in the chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by the chairman, Allen Rogers. The proposed Tentative Specifications for Soya Bean Oil, Raw or Refined, and the proposed Tentative Specifications for Perilla Oil, Raw or Refined, were accepted for publication as tentative standards.

The proposed Tentative Specifications for Raw Tung Oil were accepted for publication as a tentative standard, with the understanding that when adopted as standard they will supersede the present Standard Specifications for Purity of Raw Tung Oil (D 12–16).

The proposed revised Tentative Definitions of Terms Relating to Paint Specifications (D 16 – 21 T) were referred to letter ballot of the Society for adoption as standard to be added to the present Standard Definitions of Terms Relating to Paint Specifications (D 16 – 15) when the Book of A.S.T.M. Standards is next published.

The proposed Tentative Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green, were accepted for publication as a tentative standard.

The committee withdrew the report of its Sub-Committee XV on Specifications for Pigments, which included certain proposed revisions of existing tentative specifications for pigments and certain new tentative specifications for pigments.

The reports of Sub-Committees XXII on Method of Application of Paint by Spraying and XXIII on Anti-Fouling Paints were presented by their respective chairmen, R. E. Rogers and A. M. Muckenfuss; and on motion the report of the committee as amended was adopted.

The following papers were then presented and discussed:

"Relation of Yield Value and Mobility of Paints to Their So-Called Painting Consistency," by J. E. Booge, E. C. Bingham, and H. D. Bruce, presented by Mr. Bingham.

"Some Physical Properties of Paints," by P. H. Walker and J. G. Thompson, presented by Mr. Thompson.

"Accelerated Weathering of Paints on Wood and Metal Surfaces," by Harley A. Nelson, presented by the author.

"An Analysis and Comparison of Systems of Color Measurement and Some Notes on Interchangeability in Color Measurement," by H. S. Busby, presented by the author.

"An Application of the Pfund Colorimeter to the Determination of Tinting Strength of White Pigments," by J. H. Calbeck and C. P. Olander, presented by Mr. Calbeck.

"Hiding Power of White Pigments," by R. L. Hallett, presented by the author.

The meeting then adjourned till the following morning.

TENTH SESSION—FRIDAY, JUNE 30, 9.30 A. M.

On Lime, Gypsum and Ceramics.

(Held simultaneously with the Eleventh Session.)

President C. D. Young in the chair.

The report of Committee C-7 on Lime was presented by the chairman, H. C. Berry. The proposed revised Tentative Specifications for Quicklime for Structural Purposes (C 5 – 21 T) and for Hydrated Lime for Structural Purposes (C 6 – 21 T), with revisions recommended in the report of the committee, were continued as tentative. Certain minor modifications in the latter specifications intended to clarify the meaning were proposed by the committee and accepted.

The following proposed tentative specifications were accepted for publication as tentative standards, with minor typographical corrections:

Specifications for:

- Quicklime and Hydrated Lime for Use in the Cooking of Rags for the Manufacture of Paper;
- Quicklime and Hydrated Lime for Use in the Manufacture of Sulfite Pulp;
- Hydrated Lime for the Manufacture of Varnish;
- Quicklime and Hydrated Lime for Use in the Textile Industry;
- Quicklime and Hydrated Lime for the Manufacture of Silica Brick.

The proposed Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products, and the proposed Tentative Definitions of Terms Relating to Lime were accepted for publication as tentative standards.

The proposed Tentative Method for Determination of Available Lime in Quicklime and Hydrated Lime was accepted for publication as tentative as an integral part of the present Tentative Methods of Chemical Analysis of Limestone, Lime and Hydrated Lime (C 25 - 21 T).

An appendix to the report, discussing effect of hydrated lime in portland cement concrete, was presented in the form of papers by the following members of the committee: H. F. Clemmer (represented by F. Burggraff), W. E. Emley, T. B. Shertzer and H. C. Berry.

On motion, the report of the committee, as amended and including the appendix, was adopted.

The report of Committee C-11 on Gypsum was presented by W. E. Emley, chairman. The Tentative Specifications for Gypsum (C 22 - 21 T), with revisions recommended in the report of the committee, were continued as tentative.

The Tentative Specifications for Calcined Gypsum (C 23 - 21 T), with revisions recommended in the report of the committee, were referred to letter ballot of the Society for adoption as standard.

The proposed revisions of the Tentative Specifications for Gypsum Wall Board (C 36 - 21 T) and of the Tentative Specifications for Gypsum Plaster Board (C 37 - 21 T), in the form of proposed new specifications, were accepted for publication as tentative.

The Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 21 T), with revisions recommended in the report of the committee, were continued as tentative.

An appendix to the report of the committee in the form of a paper by J. M. Porter entitled "Gypsum Plaster and Wall Boards" was presented by title by the chairman, with the explanation that it had furnished the basis for the revision in the Specifications for Wall Board and Plaster Board.

On motion, the report, including the appendix, was adopted.

The report of Committee C-4 on Clay and Cement Sewer Pipe was presented by the vice-chairman, A. J. Provost, Jr., in the absence of the chairman, Rudolph Hering. The committee presented an addendum to its report, comprising proposed revisions in the Standard Specifications for Clay Sewer Pipe (C 13 - 20) and for Cement-Concrete Sewer Pipe (C 14 - 20) agreed upon by unanimous action at a meeting held during the annual meeting, at which 18 of the 27 members were present. These revisions, which are identical in the two specifications, are as follows:

Section 6.—Omit the last sentence. Add to the preceding sentence the words "except that in no case shall the number of specimens furnished be less than five."

Section 7.—Insert after the word "test" in the seventh line, the words "without charge." Omit the words "without charge" in the eighth line and substitute the words "to be selected as specified in Section 6." Add a new paragraph to read as follows:

> "In addition to the foregoing requirements, failure of individual specimens to develop 75 per cent of the average crushing strength requirements shall be cause for rejection of the shipment, but the seller may cull the pipe and submit the balance of the shipment for re-test, and, if the shipment then passes all of the requirements of these specifications, it shall be accepted."

Section 11.—Omit the portion of the last sentence reading as follows:

"and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00"

Table II.—Amend Table II to read as follows:

Internal Diameter, in.	Average Crushing Strength, lb. per lin. foot.		Maximum Absorption, per cent.
	Knife Edge[1] and Three-Point[2] Bearings.	Sand Bearing.[3]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8
39	3300	4710	8
42	3520	5030	8

[1] See Section 11. [2] See Section 12. [3] See Section 13.

The proposed revisions were accepted for publication as tentative provided a subsequent letter ballot vote of the committee is favorable, and the report of the committee as amended was adopted with this understanding.[1]

The report of Committee C-6 on Drain Tile was presented by Anson Marston, chairman, and adopted.

The report of the Society's representatives on the Joint Concrete Culvert Pipe Committee was presented by Anson Marston, chairman, who described the activities of the Joint Committee and especially the investigation at the Iowa Engineering Experiment Station on determination of actual loads on pipes and the development of the true theory of loads on pipes in culverts.

The report of Committee C-10 on Hollow Building Tile was presented by its chairman, W. A. Hull, and adopted.

The report of Committee C-3 on Brick was then presented by its chairman, T. R. Lawson. The recommendation of the committee that the seven sizes and types of paving brick agreed upon in a conference organized by the Department of Commerce, as reported by the committee, to be published as tentative in the form of a proposed revision of the Standard Specifications for Paving Brick (C 7 – 15), was approved.

The chairman reported that the proposed Tentative Specifications for Concrete Building Brick that were made a part of the committee's report as preprinted had failed of adoption in the committee on letter ballot vote, the vote being affirmative 10, negative 12. Mr. Lawson explained that many members of the committee had felt there were hardly sufficient data before them to pass favorably on the specifications and therefore moved to withdraw the proposed specifications and the appendix to the report containing data from a series of tests of concrete brick and concrete brick masonry. This motion was carried, and the report as thus amended was adopted.

The report of Committee C-8 on Refractories was presented by R. C. Purdy, chairman, who called on W. A. Hull to present the data in Appendix I on "Thermal Conductivity in Specifications for Refractories." On motion, the report was adopted.

The meeting then adjourned till 8 P. M.

ELEVENTH SESSION—FRIDAY, JUNE 30, 9.30 A. M.

On Petroleum Products, Insulating Materials, Textiles and Rubber.

(Held simultaneously with the Tenth Session.)

Florus R. Baxter in the chair.

The report of Committee D-2 on Petroleum Products and Lubricants, C. P. Van Gundy, chairman, was presented by the secretary, K. G. Mackenzie. The Tentative Method of Test for Melting Point of Paraffin Wax (D 87 – 21 T) was referred to letter ballot of the Society for adoption as standard.

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[1] The letter ballot vote of the committee taken on the revisions subsequent to the annual meeting resulted as follows: Affirmative, 18; negative 0; not voting, 9.

The Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 21 T), with the amendment recommended in the report of the committee, was referred to letter ballot of the Society for adoption as standard.

The proposed revisions of the Standard Methods of Testing Lubricants (Specific Gravity, Free Acid, Carbon Residue, Viscosity) (D 47 – 21) were accepted for publication as tentative.

The Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 21 T), with revisions recommended in the report of the committee, was continued as tentative.

The following proposed tentative methods were accepted for publication as tentative standards:

Tentative Method of Test for Melting Point of Petrolatum;
Tentative Method of Test for Sulfur in Petroleum Oils Heavier Than Illuminating Oil;
Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline.
Tentative Method of Analysis of Grease.

The recommendation of the Committee that the Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Petroleum Products (D 89 – 21 T) be withdrawn to be replaced by the above mentioned Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline, was approved.

Mr. Mackenzie reported that a proposed revision of the present Tentative Method of Test for Distillation of Gasoline, Naptha, Kerosene and Similar Petroleum Products (D 86 – 21 T), comprising the omission of the requirement that the bulb of the distillation thermometer shall be covered with absorbent cotton—Section 8 (*c*) of the method—had been approved by letter ballot vote of the committee, 24 affirmative, 11 negative, 3 not voting, but had been withdrawn from the report as preprinted by the committee at a meeting held June 29, the vote being 12 affirmative, 10 negative. Mr. Mackenzie then moved the adoption of the report, omitting the reference to the proposed revision of the method of test for distillation. It was moved by Thomas Midgely, Jr., to amend this motion by including in the report the proposed revision of the Tentative Method of Test for Distillation of Gasoline, etc. (D 86 - 21 T). This amendment was lost by a vote of 11 affirmative, 20 negative. The original motion was then carried without a dissenting vote.

A paper by T. G. Delbridge entitled "The Problem of Durability Tests for Transformer Oils" was then presented by the author and discussed.

The report of Committee D-9 on Electrical Insulating Materials was presented by its chairman, F. M. Farmer. The Tentative Methods of Testing Molded Insulating Materials (D 48 - 21 T) were referred to letter ballot of the Society for adoption as standard.

The committee proposed certain revisions in the Tentative Methods of Testing Insulating Varnishes (D 115 - 21 T) in addition to those included in its report, as follows:

Eliminate all reference to "fire point" because experience shows that it is unimportant in these varnishes if the flash test is made.

Section 4.—Replace with the following:

> "*Procedure for Flash Point.*—The flash point test shall be made in accordance with the Standard Test for Flash Point of Volatile Flammable Liquids (D 56 - 21) of the American Society for Testing Materials."

Section 5.—Omit entirely and renumber the remaining sections.

The committee also withdrew the two proposed new sections dealing with "Solid Content" and "Rate of Evaporation."

These revisions, as amended, were approved, and the Methods as thus amended were continued as tentative.

The proposed Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies and the proposed Tentative Methods of Test for Momentary Dielectric Strength of Sheet Insulating Materials were accepted for publication as tentative standards.

On motion, the report as amended was adopted.

The report of Committee D-13 on Textile Materials was presented by its chairman, A. E. Jury. The proposed Tentative Specifications for Imperfections and Tolerances for 60-in. 17¼-oz. Square-Woven Builder Fabric (Made of Yarn not Less than 8 Ply) were accepted for publication as a tentative standard to replace the present Tentative Specifications for Imperfections and Tolerances for 60-in. 17¼-oz. Square-Woven Tire Builder Fabric (D 122 - 21 T).

The Tentative Methods of Testing Textiles (D 76 - 20 T) and the Tentative Definitions of Terms Relating to Mechanical Fabric (D 123 - 21 T), with revisions recommended in the report of the committee, were continued as tentative.

The proposed Tentative Methods of Testing Cotton Fibers were accepted for publication as a tentative standard.

On motion, the report of the committee was adopted.

A paper on "Methods for Conducting Physical Tests on Rubber Products," by A. H. Nuckolls, was presented by the author.

A paper by W. W. Evans entitled "Accelerated Aging Tests on Rubber Goods" was presented by the author and discussed.

The report of Committee D-11 on Rubber Products was presented by its chairman, F. M. Farmer. The proposed Tentative Methods of Testing Rubber Products, with certain minor modifications by the committee, were accepted for publication as a tentative standard to replace when adopted the present Standard Methods of Testing Cotton Rubber-Lined Hose (D 15 - 15).

The following tentative standards, with revisions recommended in the report of the committee, were continued as tentative:

Tentative Specifications for:

Cotton Rubber-Lined Fire Hose for Private Fire Department Use (D 14 - 21 T);
Commercial Adhesive Insulating Tape for Electrical Purposes (D 69 - 21 T);
Rubber Insulating Tape (D 119 - 21 T);
Rubber Gloves for Electrical Workers on Apparatus or Circuits not exceeding 3000 volts to Ground (D 120 - 21 T).

The proposed Tentative Specifications for Rubber Pump Valves were accepted for publication as a tentative standard.

On motion, the report of the committee as amended was adopted.

The meeting then adjourned till 8 P. M.

TWELFTH SESSION—FRIDAY, JUNE 30, 8 P. M.

On Cement and Concrete.

Robert W. Lesley in the chair.

The chairman called for the report of the Entertainment Committee, E. D. Boyer, chairman. Mr. Boyer stated that the Sixth Annual Golf Tournament and the Second Annual Tennis Tournament had been most successfully held that afternoon at the Seaview Golf Club. On behalf of the committee he awarded the following prizes, of which a number have been donated by certain standing committees of the Society:

GOLF TOURNAMENT.

For Low Score for the Course:

The A.S.T.M. Championship Cup (A-1) and Medal	F. G. Breyer, Palmerton, Pa.

For the Lowest Net Score:

First Prize—Wrist Watch (B-2)	L. R. Ferguson, Philadelphia, Pa.
Second Prize—Traveling Clock (C-1 and A-2)	R. E. Griffith, Philadelphia, Pa.
Third Prize—Traveling Bag (C-9)	W. H. Hendricks, New York City.

For the winner of the "Blind Handicap":

Golf Bag (A-1)	J. McE. Sanderson, Buffalo, N. Y.

Other Prizes Awarded:

Best Total Gross Score—Holes 3, 6, 10, 18—Wallet (B-2)	John A. Findley, Pittsburgh, Pa.
Best Total Gross Score—First 9 Holes—Golf Head (B-2)	W. B. Price, Waterbury, Conn.
Best Total Gross Score—Second 9 Holes—Golf Head (B-2)	G. D. White, Newark, N. J.

TENNIS TOURNAMENT.

First Prize—A.S.T.M. Championship Cup (D-1) and Medal	R. W. Seabury, Boonton, N. J.
Second Prize—Silver Medal (D-1)	L. P. Nemzek, Philadelphia, Pa.

The report of Committee C-1 on Cement was presented by the chairman, R. S. Greenman, and adopted.

The report of Committee C-2 on Reinforced Concrete was presented by its chairman, Richard L. Humphrey. The proposed Tentative Rules for Inspection of Concrete and Reinforced Concrete Work were accepted for publication as a tentative standard, and the report of the committee was adopted.

The report of the A.S.T.M. representatives on the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete was presented by Richard L. Humphrey, chairman. Mr. Humphrey outlined briefly the activities of the Joint Committee during the year and spoke of tests that are being planned to try out the tentative specifications offered a year ago by the Joint Committee. Following the presentation of the report, criticisms of these specifications that had been prepared at the request of the Executive Committee by certain of our standing committees were presented in abstract as follows, with the explanation that the detailed reports had already been submitted with two exceptions to the Joint Committee:

Report from Committee C-1 on Cement, presented by R. S. Greenman;

Report from Committee C-9 on Concrete and Concrete Aggregates, presented by A. T. Goldbeck;

Report from Committee D-4 on Road and Paving Materials, presented by A. T. Goldbeck;

Report from Committee C-7 on Lime, presented by T. B. Shertzer;

Report from Committee C-2 on Reinforced Concrete, presented by D. A. Abrams.

This was followed by a general discussion of the Joint Committee's report. As part of this discussion, a paper entitled "A Method for Measuring Sands in an Inundated Condition," was read by R. L. Bertin, and accepted for publication in the Proceedings.

On motion, the report of the A.S.T.M. representatives was accepted as a report of progress.

A paper on "Fatigue of Concrete" was presented, in the absence of its author, H. F. Clemmer, by F. Burggraff and discussed.

A paper by F. E. Richart and E. E. Bauer entitled "Relations between Voids and Plasticity of Cement Mortars at Different Relative Water Contents" was presented by Mr. Richart.

There being no further business, the Chair declared the Twenty-fifth meeting adjourned *sine die*.

AMERICAN SOCIETY FOR TESTING MATERIALS.

ORGANIZED IN 1898.
INCORPORATED IN 1902.

PROCEEDINGS.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

A QUARTER CENTURY OF PROGRESS.

ANNUAL ADDRESS BY THE PRESIDENT, C. D. YOUNG.

JUNE 27, 1922.

There is an unwritten rule or custom in the American Society for Testing Materials, which is as well established as the unwritten constitution of Great Britain, that the presiding officer at each Annual Meeting shall deliver an address appropriate to the time and occasion. What is said by me tonight in compliance with that custom will be in the nature of an informal talk rather than a formal address and will be confined principally to the growth of our Society, its place in the engineering world and its relation to other engineering societies.

We are assembled this week at Atlantic City, the world's greatest playground, not only for pleasure and recreation but also for serious deliberation with reference to the activities of our members during the past year, whether as individual contributors in the form of papers or collectively by joint activities of committees.

This year marks the twenty-fifth anniversary of our existence as a Society. This assembly partakes of the nature of a silver anniversary, which our Entertainment Committee has endeavored to commemorate by the use of suitable badges.

Therefore, I shall attempt to review very briefly the growth and accomplishments of our Society since its organization and make a small but deserved contribution to the history of an association which now ranks very high among the leading scientific societies of the United States.

On June 17, 1898, what is now known as the American Society for Testing Materials had its inception in an organization formed by the American members of the then existing International Association for Testing Materials. The object of the new organization was to bring together as many as possible of those interested in the subject of materials of engineering, to simplify the work of the then existing International Association, and to render its work more efficient. One of its main objectives was to harmonize and standardize specifications for materials. The courageous group who formed this organization found progress along this line very difficult. One of the principal handicaps which confronted them was the lack of appreciation of the benefits of standardization, uniformity of the methods of testing and a common nomenclature. For this reason consumers and producers alike hesitated to engage in the preparation of any standards which might, in their judgment, tend to restrict or interfere with the standards which had theretofore or might thereafter be established or recommended by engineers or manufacturers.

During the next four years but little was accomplished to carry out the paramount objects of the Association, and had it not been for the personal pride of its founders and their praiseworthy determination to carry out those objects, this Society might have failed of its purpose and passed into the realm of innocuous desuetude many years ago. At that time many of our members felt that this association could succeed only as an independent American institution and not as a body subordinate to an International Association. This feeling grew until 1902, when it was expressed in the incorporation and organization of the American Society for Testing Materials. From that time on its membership grew at a steadily increasing rate, and this growth has continued from that time to this with a remarkable uniformity, so that at present more than one-fourth of its members are actively devoting themselves to committee work, and many of those not so situated as to be able to give the time required for such work are contributing through papers to the advancement and knowledge of engineering materials and approved methods for testing them, If I were asked what is the most characteristic feature of our Society. I would answer that it is the independence of its members from preconceived notions and arbitrary standards. This is conclusively shown by the fact that it did not justify its existence by its growth until after it had freed itself from the limitations placed upon it by the old International Association, which tended to restrain its scope to methods of testing and to academic discussions of what a specification should be, instead of permitting the greatest freedom in the establishment of American standards of testing.

Not until after our Society had become autonomous was it possible to prepare standard methods of testing through collaboration and research work nor to adopt acceptable standard specifications. The untrammelled initiative of our members has been the guiding spirit of our Society for the last twenty years, and finds its natural expression in the work of our widely diversified standing committees. Through regulations applicable to the needs of each committee, our form of management is unique as compared with that of other engineering societies, because it permits the freest possible expression of the views of all of our members, each of whom has an equal voice in the work brought formally to the attention of the Society for mass or group adoption. This method of conducting the business of the Society gives to each producer, consumer or independent engineer a fair chance to speak and be heard and to present to committees of each group all angles and phases of the problems to be considered.

As this Society became established as an independent entity, prejudice against its work gradually disappeared until it had no rival in its chosen field. At first there was none so poor as to do it reverence; but soon there was none to challenge its supremacy. Since the establishment by it of standardized methods and specifications, increasing recognition has been given us as the authoritative body not only in a few, but on all, subjects relating to materials engineering. Such great strides have been made that the Society has produced standards covering nearly all of the important materials generally used in engineering construction. These standards, together with those which are now contemplated and are in course of development, will, when completed, afford to the engineer the necessary guides in engineering practices. In the preparation of these standards, the fullest cooperation has been obtained from manufacturers and producers, and the standardization thereby effected has enabled the buyer and the seller to speak the same language. In overcoming the prejudice against standardization, the manufacturer has learned that it is possible for him to produce a far better quality of product, and at the same time greatly reduce his expenses through mass production. This lower cost makes it possible not only to offer to the public better materials at lower unit prices, but also to maintain at the same time higher wages for labor.

American standards of quality, having forced recognition throughout the world, have stabilized production and employment through the broadening effect of increased markets, and have made it safe for manufacturers to accumulate stocks during dull periods, when, without such standards, such a policy would have been extremely hazardous not only to the manufacturer but also to the general public.

Although standardization restricts the varieties for selection, it permits concentration of thought and skill upon design, so that the product may be more economically and efficiently handled. It also reduces the maintenance cost of the finished structure by simplifying the stocks necessary for their maintenance. These well-established standards have established that factor of safety which is essential for the engineer in making the finished product. Moreover the care which is exercised by the committees in the preparation of their standards gives full assurance to the public that the materials purchased and inspected in accordance with the recommendations of this Society will result in furnishing the best that can be produced, at the lowest possible cost, and at the same time will afford all safety necessary to the public welfare.

In the formation of our committees great care is exercised in making the selections so that all views and interests will be represented by the personnel composing the committees, because long experience has demonstrated the fact that with a committee not wholly representative of the industry involved in the standard under consideration it is impossible for that standard to win general recognition.

Furthermore, even after a truly representative committee, selected from the fields of engineering, research and manufacture, has reached an agreement, experience has taught us that any work offered for acceptance as a standard cannot be ultimately adopted until all of the interests involved in the problem have adjusted their ideas to the common standard, and have unanimously accepted the mosaic thus produced. How often have we seen at our annual meetings standards and methods fail of adoption because they have not had the unanimous support of all the interests involved! And how frequently has it occurred that an objection voiced at first only by one of our members has been sufficient after discussion to cause a recommendation to be referred back to the committee for further consideration! Is it not apparent, therefore, that the secret of the success of such standards as have been finally adopted as a matter of record by this Society is due to such thorough consideration and unanimous approval? If, on the other hand, either in a committee, or at an annual meeting, objection is made on the ground that the adoption of the recommended standard would prevent some particular manufacturer from marketing a special article, or some engineer from gaining advantage through special design or otherwise, seldom has such an objection been supported, for as soon as its true significance has been revealed the standard recommended by the committee is supported by the membership at large. And this experience, frequently repeated, shows why our standards are being so frequently endorsed and generally used.

Other technical societies and governmental agencies, recognizing the worth of our procedure and standards, are looking more and more to this body as the authority on standards of materials, and for assistance in preparing specifications, nomenclature and methods of testing. Therefore we point with just pride to the abundant evidence that when our allied engineering associations desire to incorporate such specifications as a portion of their work, they adopt ours. As conclusive evidence of this fact we find our standard materials specifications in the Boiler Code of the American Society of Mechanical Engineers, our joint work on cement in the American Society of Civil Engineers, and our standards covering the quality of and tests for certain electrical materials in the standards of the American Institute of Electrical Engineers. More recently the American Engineering Standards Committee has named this Society as sponsor for six standardization projects and has adopted as American Standards or Tentative American Standards fourteen specifications promulgated by us. The United States Department of Commerce, recognizing the value of the work of this Society, has translated and broadcasted through its various consulates sixty-one of our standards translated into Spanish and French, and the translation is now contemplated of about forty of them into Portuguese for use in Brazil. The leading manufacturers of the country are offering as their recommended practice the standards of our Society, and it is with pleasure we observe that in the recently "Recommended Minimum Requirements for Small House Construction" tentatively prepared by the Building Code Committee of the Department of Commerce, the standards of the Society are offered wherever specifications for materials are mentioned. The Interdepartmental Petroleum Specifications Committee of the U. S. Federal Specifications Board has adopted all the methods of test for petroleum products developed by our Society, using other methods for determining certain properties only when the Society has not yet formulated methods for determining those properties. In the whole domain of science practically applied, what society can point to so many expressions of the unqualified approval of its accomplishments?

It is impossible tonight to present anything like a complete review of the activities of our committees during the past year. They are too voluminous and too diversified in character. Every paper presented at this meeting is a credit to our members because it reflects the greatest care in preparation. It seems appropriate, however, that, referring at random to the activities of our committees, I should point out to you a few of those which, directly or indirectly, are of especial interest to the general public. This list is not complete, for, indirectly at least, all of our work affects American economic life. It is worthy of note, however, that Committee A-1 on Steel, in cooperation with the American Railway Association, has completed a study of specifications covering castings for railways, which affect the safety of passengers and afford protection to merchandise. This is a distinct advance in the requirements for such castings. Our Committee A-3 has been actively engaged in producing a specification for better cast-iron wheels, so essential to the safety of transportation, and our Committee on Corrosion of Iron and Steel, through its painstaking and elaborate physical tests, will, upon the completion of its work, establish facts which will aid the engineer in his selection of grades that will increase the wearing quality of exposed iron and steel. Committee C-1 on Cement is planning to continue research work and a study of cements embracing not only methods of tests but also the effect that other admixtures, used with cements, have upon the cement when made into concrete.

Committee C-2, engaged in the study of reinforced concrete, will recommend a practice on a matter which is of great public interest, in that it affects the safety of concrete buildings. This recommendation is an endeavor on the part of our committee to present to the public a recommended practice for strict observance of the proper inspection of concrete and reinforced concrete structures.

Our Drain Tile Committee, in cooperation with other agencies, is conducting an extensive investigation to determine the effect of acids and alkali solutions on concrete drain tile. The result of this investigation will, no doubt, have a marked effect upon drainage construction, and, through cooperative action with the U. S. Department of Agriculture, will result in very great benefit to the American farmer.

Committee D-1 through its study on methods of the application of paint by spraying and certain tests of anti-fouling paint for use on ship bottoms, is making a valuable contribution to the subject of commercial economics. If, through its work, the time now lost through dry docking and cleaning of ships is materially reduced, the economic gain to all is obvious.

Our committees on Petroleum Products and Lubricants (D-2), as well as on Road and Paving Materials (D-4), are working on the first essential step before general standardization can be agreed upon, that is, methods of testing the products of such groups. Committee D-2 is making excellent progress in the standardization of methods which will facilitate the preparation of specifications for gasoline, fuel oil and other petroleum products of daily use in almost every family. And likewise Committee D-4 is engaged in the important work of standardizing the methods of testing road materials, which will be of great assistance in the road construction program of this country; and it should be a matter of pride to our members to know that the various State Highway Departments are looking to this Society for standardized methods of test covering materials necessary for their use in highway construction. The progress of this committee is particularly gratifying in view of the marked prejudices which must of necessity be eliminated in order to work out methods of tests and specifications which will prove universally acceptable.

The subjects of study which I have brought to your attention will indicate how closely they affect the average man on the street, for, although he may not feel a personal interest in the technical details, it must be apparent to him that practically all of the work of the members of this Society, both directly and indirectly, affect him in a marked degree, in that our Society, through its efforts to advance the knowledge of engineering materials, and to establish proper methods of testing and correct make-ups of specifications, is making rapid strides in the improvement of our economic life in ways too numerous to mention.

This Society does not seek to monopolize all of the field of engineering materials, because our fixed policy has been, as expressed in our Regulations, not to go beyond Materials nor to invade the engineers' field of design, but through cooperative action to give the benefit of the knowledge of our members to the general public. With other societies we are actively engaged in a study of improvement in, and specifications for, insulated wire and cables, and the preparation of standards for concrete culvert pipe. Through joint committee action, we are also working upon specifications for concrete and reinforced concrete. This work has taken on a far reaching and important aspect, in that the previous work of the committee is now being reviewed, and tests of the practical merit of the proposed specifications are being actively carried out in the larger cities of the country on important construction work, for the purpose of ascertaining the desirability of following these recommendations as standard practice, before determining whether or not they are complete and economically correct.

Your Executive Body, through its standing Committee on Inter-Society Relations, is in cooperative contact with all material engineering agencies of America, and is affording them a knowledge of materials together with every assistance possible.

As our knowledge increases, it is very important that revisions of our adopted standards be made from time to time, for if no recognition be accorded to the increased scientific knowledge, the introduction of known materials applied to new devices, or of new products to old uses, stagnation in the work of our Society would result, and, with the demand for increased knowledge of materials in other allied Engineering Societies, our position would soon be usurped by them. We must, however, look with caution upon each proposed modification of standards and methods, and determine beyond doubt that suggested changes are based upon practical knowledge, born of the experience of those who are best qualified to pass upon the changes proposed. It goes without saying that the necessity for modification outweighs the desirability for maintaining any given standard, proper consideration being given at all times to the disturbing effect which such proposed changes may have upon production processes essential to economic output. Here again our Society has seen the effect of the personal equation applied to some of our country's largest industries, in that the members of our Society who are connected with such industries, through round table discussion on some vital point, come to a common agreement that a better product can be specified, notwithstanding the effect which such changes may have on their processes of production. Thus a new standard may be accepted by the industry, and, without delay or friction, a better quality of product furnished to the general public for its safety and economic gain. In this way the purpose of our founders, that our Society should afford a meeting ground for manufacturers, engineers and consumers, in establishing standards of methods of testing and unification of specifications, may be realized in greater measure than was thought possible a quarter of a century ago when prejudices against such unification were so strongly entrenched.

That our Society is furnishing the means for assistance, through its ability to establish the closest relationship with the different interests using and producing materials, is well illustrated by the very rapid growth in receipts from the sale of its publications. Beginning in 1902, with receipts amounting to fifty-four dollars ($54) from this source, the amount has steadily grown until, during the past year, the revenues from that source amounted to eighteen thousand dollars ($18,000), representing more than one-fourth of the financial income of the Society. With the problem before the Executive Committee of furnishing the greatest returns to our members for their dues, in the way of publications, these sales represent a very material asset to our budget. This, however, is not the true measure of the importance of these sales, but rather indicates the standing and utility of our publications to those interested in our work. The fact that they are buying them voluntarily conclusively proves their worth.

In the report of the Executive Committee our Secretary has presented a complete analysis of the manner in which our funds are being expended. This is called to your attention because it illustrates in a very striking manner the efforts of that committee to return to the members the maximum return in publications, consistent with the funds of the Society. During the past few years there has been a marked increase in the cost of our publications, but, without assessing additional cost upon our members, there has been no marked decrease in the volume of the publications distributed.

As American engineers have found our standards adequate in quality for this country's needs, making it unnecessary to seek foreign markets for materials to meet the most exacting requirements, it seems to us that our neighbors could, to their advantage, avail themselves of this quality to satisfy conditions which are similar to ours. To this end our Committee on Papers has been actively considering what further can be done with due regard to our resources, towards increasing the technical literature which may be distributed by the Society. The Executive Committee is carefully considering ways and means for further circulating our Proceedings in foreign countries, so that American standards may be more generally known and more frequently specified. The interest taken by our members in this matter is exceedingly gratifying to your Executive body, which sees, through the medium of the distribution of our publications, a better understanding by foreign countries of questions affecting the merits of American products in the commercial exchange between this country and others.

Our Society should strongly support any movement which will again create an international association of testing engineers. As already mentioned, our Society did not find the desired possibility of growth under the handicap of the original International Association. Now, however, it seems that with a better understanding of the limitations of the old International Association, with its restrictive requirements in limiting the activities of its members to what might be termed academic discussions, it is possible, as well as desirable, that the International Association be re-established, for the purpose of further developing the knowledge of engineering materials and stimulating the science of testing materials, resulting in the creation of international specifications which might be adopted for general use. It is the duty of this Society to lend its influence in the re-establishment of such an active Association. Our recognized standing has placed us in a position to actively promote such a movement, and, when, in the judgment of this body, the time has arrived for the re-establishment of such an Association we should be ready at once to give the movement our hearty support.

The economic conditions resulting from the war may be viewed by some as a barrier to the revival of the International Association; but I do not concede the correctness of that opinion. Moreover the desirability of such revival is so apparent that a careful study of the conditions involved should be made for the purpose of determining whether or not such a consummation is possible.

Standardized knowledge is a *sine qua non* of economic development. Science is the handmaid of progress, and her standards, to be worthy of adoption, must be both exact in conception and clear in their expression. While we must be conservative, we must in many things take the initiative. But as we are members of a purely voluntary association, every standard we seek to establish, the ultimate results of all tests for which we are responsible, and all recommendations we make, must be presented on their own merits and not upon any mere *ipse dixit*. We have no sordid objectives to accomplish, no selfish business or personal interests to serve. Our aims are and must be purely altruistic.

This Society is a clearing house for the discovery and application only of those principles which are sound and those practices that have been tested before they obtain our full sanction. This forum is always open, and for the advancement of the work to which it is dedicated "every hour is noon." But while it is our duty to reject every engineering fad, fancy and fallacy which seeks our approval, that duty is best performed by burying them quietly in unmarked graves, for, as expressed in the well-known maxim, "Public reproof hardeneth the heart."

In one of the numerous bibles which have been promulgated by *man* we read this injunction, "Blessed is he that bloweth his own horn; for whosoever bloweth not his own horn, his horn shall not be blown." But in the Bible which our mothers read to us we find these words, which appeal alike to our faith and to our reason: "Let not him that girdeth on his harness boast himself as he that putteth it off." And so, but not otherwise, shall we "prove all things" and "hold fast that which is good." And thereby we shall justify the respect and confidence and deserve the commendation not only of leading scientists abroad but especially in our own country, which is so fortunate as to stand in the vanguard of modern civilization.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE.

The Executive Committee offers the following report of general Society activities for the past year:

Membership.—Membership statistics for the past year are shown in the following table:

	1921 Annual Meeting.	1922 Annual Meeting.	Transfer.	Losses.			Additions.		Totals.		
				Resignation.	Dropped.	Death.	Transfer.	Election.	Loss.	Gain.	Increase.
Honorary Members	4	3	..	...	...	1	..	...	1	...	1[a]
Members	2,719	2,871	..	162	96	20	51	379	278	430	152
Junior Members	185	156	51	7	18	..	..	47	76	47	29[a]
Totals	2,908	3,030	51	169	114	21	51	426	355	477	122

[a] Decrease.

The membership of the Society has passed the three thousand mark, the membership now being 3030. The net increase in membership for the year is 122 compared with 154 for the previous year. Both of these figures are considerably below the net increase in membership of two years ago, which was 273. The Executive Committee feels that this is undoubtedly to be explained by the period of financial stringency which has been experienced and it is gratifying to be able to report that the "membership increase" curve is showing a greater upward slope. Since the first of the year there has been an increase in the number of new members elected, which has resulted in raising the total of new members for the year closing with this annual meeting to 426, compared with 369 for the preceding year.

The Society has suffered the loss by death of 21 members, among them being Henry M. Howe, Past-President and Honorary Member, Alfred W. Gibbs, Past-President, S. S. Voorhees, Past-Vice-President, and W. A. Bostwick, at one time a member of the Executive Committee. Other members whose death is to be reported are:

L. N. Butz
W. B. Cogswell
T. H. A. Eastick
Henry Hess
J. M. Jeffers
R. L. Lindstrom
J. P. McNaughton
T. O. Organ
L. S. Randolph
Kenneth Rushton
K. D. Schwendener
B. E. D. Stafford
A. C. Stalknecht
Knox Taylor
G. H. Tefft
C. W. Waidner
C. H. Williams

Membership growth since the organization of the Society is shown in Fig. 1.

Standing Committees.—The Executive Committee is again able to report a year of exceptional activity on the part of our standing committees, which has resulted in a volume of committee reports of outstanding value that seldom if ever has been exceeded in the history of the Society. Of the forty standing committees, 35 are presenting reports at this meeting, and the remaining 5 have submitted brief reports to the Executive Committee indicating progress during the year. The reports presented comprise approximately 720 pages and include recommendations for proposed revisions in 23 standards (of which 2 have been previously reported), adoption of 12 tentative standards as standards, acceptance of 54 proposed new standards as tentative, and proposed revisions in 44 tentative standards to be continued as tentative.

Two new committees have been organized since the last annual meeting: Committee D-15 on Thermometers, under the chairmanship of W. H. Fulweiler, and Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, under the chairmanship of E. C. Lathrop. Detailed announcement of the organization of these committees appeared in the BULLETIN. Committee E-2 on Electrical Standards was discontinued on its own recommendation, in view of the fact that the organization of the American Engineering Standards Committee makes the further work of Committee E-2 unnecessary. The committee was originally created for the purpose of coordinating the Society's activities with those of other societies dealing with electrical matters, and the membership of the Society on the Standards Committee provides adequate means for necessary cooperative work in this field.

Regulations Governing Committees E-1 on Methods of Testing and E-8 on Nomenclature and Definitions have been duly approved during the year by the Executive Committee.

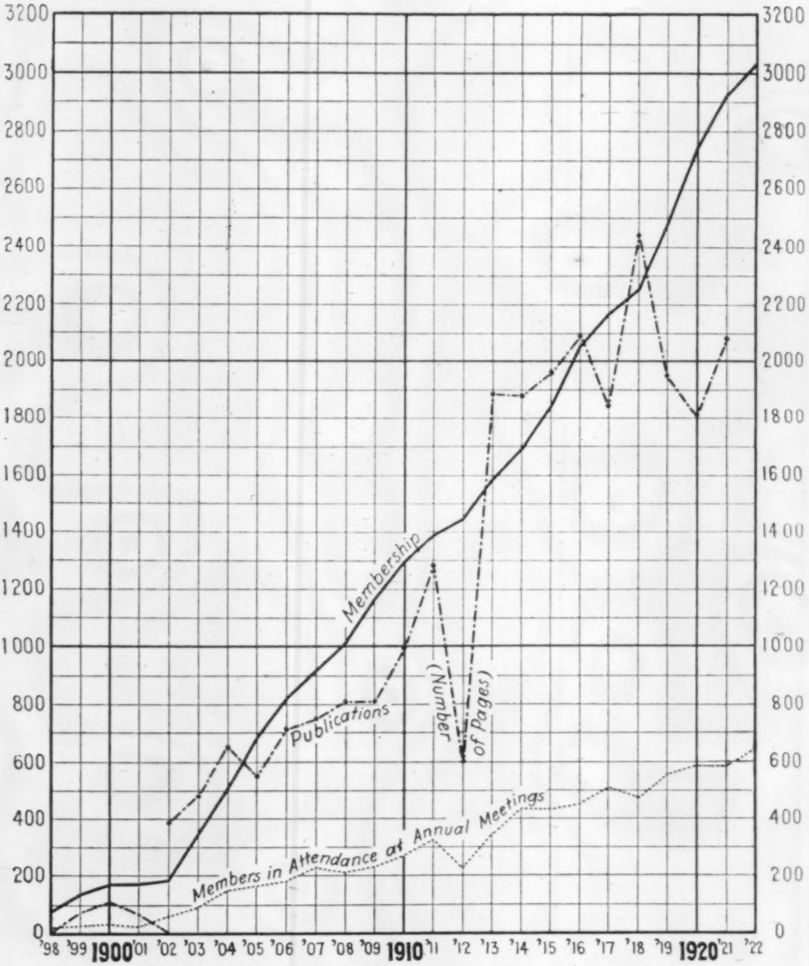

FIG. 1.—Membership and Publications Chart.

NOTE.—The initial curve for publications (1898–1902) refers to the publications of the American Section of the International Association for Testing Materials. The marked drop for 1912 in the "publications" and "members in attendance at annual meetings" curves is due to the fact that the Sixth Congress of the International Association was held in New York in September, 1912, and that the activities of the American Society for that year were accordingly restricted to committee reports and administrative business. The drops of the "publications" curve in 1917, 1919, and 1920 are explained by the fact that the Book of A.S.T.M. Standards was not published those years.

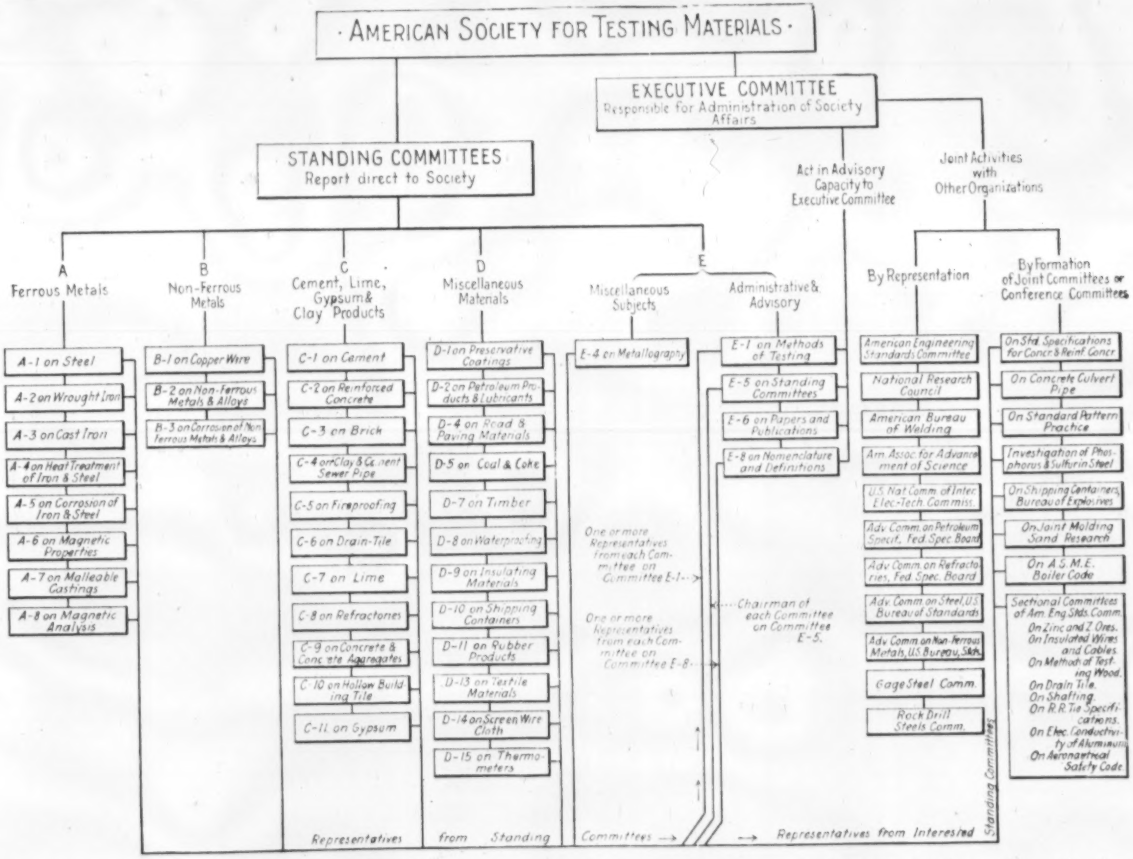
· AMERICAN SOCIETY FOR TESTING MATERIALS ·
EXECUTIVE COMMITTEE
Responsible for Administration of Society Affairs
STANDING COMMITTEES
Report direct to Society
Act in Advisory Capacity to Executive Committee
Joint Activities with Other Organizations
A Ferrous Metals
B Non-Ferrous Metals
C Cement, Lime, Gypsum & Clay Products
D Miscellaneous Materials
E
Miscellaneous Subjects
Administrative & Advisory
By Representation
By Formation of Joint Committees or Conference Committees
A-1 on Steel
A-2 on Wrought Iron
A-3 on Cast Iron
A-4 on Heat Treatment of Iron & Steel
A-5 on Corrosion of Iron & Steel
A-6 on Magnetic Properties
A-7 on Malleable Castings
A-8 on Magnetic Analysis
B-1 on Copper Wire
B-2 on Non-Ferrous Metals & Alloys
B-3 on Corrosion of Non Ferrous Metals & Alloys
C-1 on Cement
C-2 on Reinforced Concrete
C-3 on Brick
C-4 on Clay & Cement Sewer Pipe
C-5 on Fireproofing
C-6 on Drain-Tile
C-7 on Lime
C-8 on Refractories
C-9 on Concrete & Concrete Aggregates
C-10 on Hollow Building Tile
C-11 on Gypsum
D-1 on Preservative Coatings
D-2 on Petroleum Products & Lubricants
D-4 on Road & Paving Materials
D-5 on Coal & Coke
D-7 on Timber
D-8 on Waterproofing
D-9 on Insulating Materials
D-10 on Shipping Containers
D-11 on Rubber Products
D-13 on Textile Materials
D-14 on Screen Wire Cloth
D-15 on Thermometers
E-4 on Metallography
E-1 on Methods of Testing
E-5 on Standing Committees
E-6 on Papers and Publications
E-8 on Nomenclature and Definitions
One or more Representatives from each Committee on Committee E-1
One or more Representatives from each Committee on Committee E-8
Chairman of each Committee on Committee E-5.
American Engineering Standards Committee
National Research Council
American Bureau of Welding
Am. Assoc. for Advancement of Science
U.S. Nat. Comm. of Inter. Elec-Tech. Commiss.
Adv. Comm. on Petroleum Specif., Fed. Spec. Board
Adv. Comm. on Refractories, Fed. Spec. Board
Adv. Comm. on Steel, U.S. Bureau of Standards
Adv. Comm. on Non-Ferrous Metals, U.S. Bureau, Stds.
Gage Steel Comm.
Rock Drill Steels Comm.
On Std. Specifications for Concr. & Reinf. Concr.
On Concrete Culvert Pipe
On Standard Pattern Practice
Investigation of Phosphorus & Sulfur in Steel
On Shipping Containers, Bureau of Explosives
On Joint Molding Sand Research
On A.S.M.E. Boiler Code
Sectional Committees of Am. Eng. Stds. Comm.
On Zinc and Z Ores.
On Insulated Wires and Cables.
On Methods of Testing Wood.
On Drain Tile.
On Shafting.
On R.R. Tie Specifications.
On Elec. Conductivity of Aluminum
On Aeronautical Safety Code
Representatives from Standing Committees → Representatives from Interested Standing Committees

FIG. 2.—Chart Showing List and Classification of Standing Committees and Joint Activities with Other Organizations.

The matter of cooperation between Committees C-3 on Brick and D-4 on Road and Paving Materials in the consideration of specifications for paving brick has been settled through the appointment of F. H. Jackson, Jr., to represent Committee D-4 on Committee C-3. Certain suggestions of Committee D-4 relative to the Society's Paving Brick Specifications have been placed before Committee C-3 through Mr. Jackson.

After consideration of the matter, extending over a period of a year or more, the Executive Committee has decided that it is inexpedient to attempt the organization, at this time at least, of a standing committee on heavy chemicals. Suggestions have been made that the Society organize committees on Ferro Alloys, Asbestos Products, Slate and Glue, and the Secretary-Treasurer is investigating the possibilities in these directions. The organization of a Committee on Leather Belting is still under consideration.

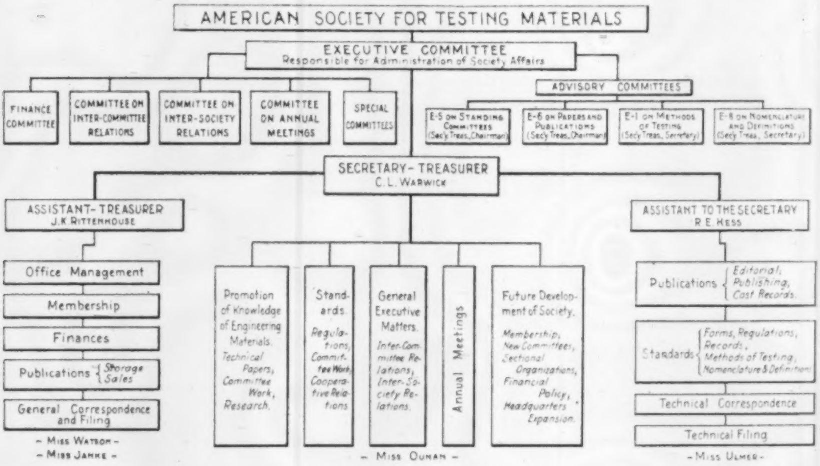
AMERICAN SOCIETY FOR TESTING MATERIALS
EXECUTIVE COMMITTEE
Responsible for Administration of Society Affairs
FINANCE COMMITTEE
COMMITTEE ON INTER-COMMITTEE RELATIONS
COMMITTEE ON INTER-SOCIETY RELATIONS
COMMITTEE ON ANNUAL MEETINGS
SPECIAL COMMITTEES
ADVISORY COMMITTEES
E-5 on Standing Committees (Sec'y Treas., Chairman)
E-6 on Papers and Publications (Sec'y Treas., Chairman)
E-1 on Methods of Testing (Sec'y Treas., Secretary)
E-8 on Nomenclature and Definitions (Sec'y Treas., Secretary)
SECRETARY-TREASURER
C. L. Warwick
ASSISTANT-TREASURER
J. K. Rittenhouse
ASSISTANT TO THE SECRETARY
R. E. Hess
Office Management
Membership
Finances
Publications { Storage Sales
General Correspondence and Filing
- Miss Watson -
- Miss Janke -
Promotion of Knowledge of Engineering Materials. Technical Papers, Committee Work, Research.
Standards. Regulations, Committee Work, Cooperative Relations
General Executive Matters. Inter-Committee Relations, Inter-Society Relations.
Annual Meetings
Future Development of Society. Membership, New Committees, Sectional Organizations, Financial Policy, Headquarters Expansion.
- Miss Ounan -
Publications { Editorial, Publishing, Cost Records.
Standards { Forms, Regulations, Records, Methods of Testing, Nomenclature & Definitions
Technical Correspondence
Technical Filing
- Miss Ulmer -

FIG. 3.—Chart Showing Organization of Executive Committee and Classification of Activities in Secretary-Treasurer's Office.

During the year the Executive Committee received a suggestion from the American Water Works Association that the Society undertake the preparation of specifications for lead pipe. After looking into the matter the Executive Committee has recommended to Committee B-2 on Non-Ferrous Metals and Alloys that they carry out this suggestion, if necessary by the creation of a separate sub-committee on the subject.

The Executive Committee includes with this report a chart (see Fig. 2) that has been prepared showing diagrammatically the committee organization of the Society. This chart brings out in an interesting way the relationship between the various standing committees, and shows how four of these committees, Committees E-1 on Methods of Testing, E-5 on Standing Committees, E-6 on Papers and Publications and E-8 on Nomenclature and Definitions, act as administrative committees and in an advisory capacity to the Executive Committee. The chart also shows how the cooperative work of the Society with other societies ties in through the Executive Committee, as required by our procedure.

The Executive Committee also includes a chart (see Fig. 3) showing diagrammatically the organization of its work and the classification of and responsibility for the various activities of the Secretary-Treasurer's office.

Special Committee on Investigation of Reinforcement Bars.—The Executive Committee reported a year ago that, at the joint request of Committees A-1 on Steel and C-2 on Reinforced Concrete, it had authorized the formation of a special committee on the subject of tests on deformed steel concrete reinforcement bars. In BULLETIN No. 3, October 25, 1921, the personnel of this committee was announced as follows:

E. E. Hughes,
Richard L. Humphrey,
A. E. Lindau,
C. F. W. Rys,
W. A. Slater,
J. J. Yates.

Mr. Humphrey was elected chairman and Mr. Slater secretary.

The original scope of the investigation, namely, the physical properties of plain and deformed concrete reinforcement bars, was extended on the recommendation of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete to include a study of the efficiency of deformed bars when used as reinforcing in concrete, with special reference to the effect of the design of the bar on its bond resistance.

The committee has reported progress in its work of organizing the investigation, a program of tests has been outlined, and the committee is now endeavoring to arrange for financial support of the investigation.

Revisions of Regulations Governing Standing Committees.—During the year the Executive Committee has approved the recommendation of Committee E-5 on Standing Committees that Section 11 on Standards of the Regulations Governing Standing Committees be modified by striking out all reference to "Standard Tests" and making Paragraph 11 (*c*) read as follows:

"The term 'Standard Methods' shall be applied to methods of testing, analysis, sampling and similar operations. Standard Methods shall not include limits for physical, chemical or other properties."

This modification was decided upon as a result of careful consideration by Committee E-1 on Methods of Testing and Committee E-5 on Standing Committees of proposed Regulations Governing the Form but not the Substance of Methods of Test, in which a complete study and classification of the Society's standard methods has indicated that the classification "Standard Tests" is unnecessary and that the classification "Standard Methods" can more logically be made to include the former.

Proposed Revisions of the By-Laws.—Consistent with the change in the Regulations Governing Standing Committees above mentioned, the Executive Committee recommends to the Society an amendment of Article VI, Section 1, of the By-laws dealing with Procedure Governing the Adoption of Standards, the amendment consisting in the omission of the words "Standard Tests" in the first sentence of Section 1: namely,

"The term 'Standards' shall be applied collectively to standard specifications, [standard tests,] standard methods and standard definitions."

It is recommended that this amendment be referred to a letter ballot vote of the membership in accordance with the requirements of the By-laws.

Publications.—The regular publications during 1921 were the Proceedings, Book of A.S.T.M. Standards and the Supplement to the 1920 Year Book. A comparative statement as to the volume of regular publications during the past three years is exhibited in the following:

	1919, Pages.	1920, Pages.	1921, Pages.
Proceedings	1601	1359	1197
Book of A.S.T.M. Standards	...	...	890
Year Book (Membership List)	298	320	...
Supplement to Book of Standards	63	128	...
Supplement to Year Book	...	...	32
Totals	1962	1807	2119

In addition, the Society published during 1921 the Book of A.S.T.M. Tentative Standards (518 pages). Last year the policy was adopted of including only new and revised tentative standards in the current Proceedings. The Book of Tentative Standards was arranged, however, to include as heretofore all of the Society's tentative standards, thus making it the only Society publication containing a complete collection of the tentative standards. The demand for this volume, which was placed on sale for the convenience of those members desiring it, was very gratifying, there having been sold during the year 585 copies to members and 80 copies to non-members.

Since the last annual meeting there have been printed four circulars to members aggregating 12 pages and four issues of the A.S.T.M. BULLETIN, two of four pages and two of eight pages. At the time of the last annual meeting only the first issue of the BULLETIN had been published. The favorable reception of that issue by the members has continued during the year, which marks the conclusion of the first year under the policy of issuing a quarterly Bulletin. The Bulletin has been of great service in announcement of current committee activities and joint activities with other societies, and in general has enabled the Executive Committee to keep the membership in much closer touch with current Society affairs than has heretofore been possible. Comments from members and committees have been uniformly favorable and the Executive Committee feels confident that the Bulletin is finding a very definite place in the Society's publications and that the members find it of interest and value.

Headquarters.—The facilities at the Society headquarters continue to be widely used by the standing committees and their sub-committees for meetings. During the period from June, 1921, to June, 1922, there were 35 committee meetings, 40 sub-committee meetings and 7 meetings of committees of other societies, a total of 82. The Executive Committee wishes to have the committees and members of the Society make use of Society headquarters in every way possible.

Finances.—The annual statement of the finances of the Society follows in the form of the report of the auditors for the fiscal year January 1, 1921, to December 31, 1921.

Attention is called to the fact that when the Society established its headquarters in the fall of 1919, it entered into an agreement with the Engineers' Club of Philadelphia by which it was to pay the cost of necessary alterations to the Club building, this sum to be accepted by the Club as advance payment of rent at the rate of $1000 a year. This agreement became effective on January 1, 1920, and the total amount paid by the Society was $4467.17.

REPORT OF AUDITORS FOR THE FISCAL YEAR JANUARY 1, 1921, TO DECEMBER 31, 1921.

JOHN HEINS AND CO.
PUBLIC ACCOUNTANTS AND AUDITORS

PHILADELPHIA, January 6, 1922.

AMERICAN SOCIETY FOR TESTING MATERIALS,
MR. C. L. WARWICK, *Secretary-Treasurer*,
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 31, 1921, having previously made a similar audit and report for the preceding six months ended June 30, 1921, and at both audits found the accounts to be correct and to be in their usual excellent condition.

We submit balance sheet as of December 31, 1921, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the last six months as also for the six months ended June 30, last, as reported in ours of July 18 and found the same to be correct.

We have verified by actual inspection and count the securities as listed on the Balance Sheet.

Respectfully submitted,
(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1921.

ASSETS.

Cash		$3,819.07	
Investments:			
$17,200 U. S. Liberty Loan Bonds, 4th 4$\frac{1}{4}$'s	$16,380.64		
1,300 U. S. Liberty Loan Bonds, 4th 4$\frac{1}{4}$'s, held for Life Membership Fund	1,227.45		
		17,608.09	
Accounts Receivable:			
For Publications	$2,969.85		
Members for 1921 dues	2,214.00		
Members for binding	34.50		
		5,218.35	
Rent paid in advance		2,467.17	
Furniture and Fixtures		2,654.17	
			$31,766.85

LIABILITIES.

Members dues paid in advance	$318.50		
Members binding paid in advance	451.50		
		$770.00	
Life Membership	$1,300.00		
Surplus	29,696.85		
		30,996.85	
			$31,766.85

MISCELLANEOUS FUNDS.

In addition to the above cash the Secretary-Treasurer has on hand the following funds:

Committee A-5 on Corrosion of Iron and Steel	$2,163.54	
Committee C-1 on Cement	2,006.73	
Committee C-9 on Concrete and Concrete Aggregates	574.68	
Committee C-10 on Hollow Building Tile	194.33	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	171.93	
		$5,111.21

RECEIPTS AND DISBURSEMENTS.
JANUARY 1, 1921, TO DECEMBER 31, 1921.

Cash on hand, January 1, 1921			$265.05

RECEIPTS.

Current dues	$41,629.46		
Past dues	557.37		
Advance dues	318.50		
		$42,505.33	
Sale of Publications:			
Separate Standards	$2,928.92		
Book of Standards	4,470.73		
Book of Tentative Standards	2,470.13		
Proceedings	3,214.74		
Miscellaneous	4,919.04		
		18,003.56	
Binding (Members)		1,248.50	
Sale of right to reprint Standards		750.00	
Authors' reprints		120.16	
Sale of Certificates of Membership		44.50	
Interest on deposits and investments		1,729.82	
Accrued interest		104.29	
Excess remittances		58.90	
Miscellaneous		11.75	
Committee A-5		725.00	
Total receipts		$65,301.81	65,301.81
			$65,566.86

DISBURSEMENTS.

Publications	$35,934.39	
Salaries	15,146.08	
Expenses, Secretary-Treasurer's Office	3,070.10	
Expenses, Standing Committees	1,168.60	
Expenses, Nominating Committee	130.00	
Traveling Expenses, Executive Committee	622.01	
Rent and Insurance, Storage Rooms	321.60	
Engrossing Certificates of Membership	4.50	
American Engineering Standards Committee	1,500.00	
Net Expenses, Annual Meeting	662.55	
Rent and Alterations	194.60	
Headquarters' Maintenance	80.12	
Furniture and Fixtures	518.77	
Girard Trust Co., Repayment of Loan	2,206.60	
Accrued interest	104.29	
Refund of excess remittances	58.90	
Miscellaneous	24.68	
Total disbursements	$61,747.79	$61,747.79
Cash on hand December 31, 1921		$3,819.07

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1917–1921, INCLUSIVE.

Fiscal Year.	Assets.					Liabilities.	Surplus.
	Cash Balance.	Investment Liberty Bonds.	Accounts Receivable.	Advance Rent and Furniture and Fixtures.	Total.	Accounts Payable.[a]	Surplus.[b]
1917	$9 584.82	....	$2 601.71	....	$12 186.53	231.00	$11 955.53
1918	7 164.93	$4 880.63	2 569.95	....	14 615.51	331.47	14 284.04
1919	294.70	15 601.58	3 415.40	$3 600.00	22 911.68	417.25	22 494.43
1920	265.05	17 608.09	3 823.90	5 897.48	27 594.52	2 608.50	24 986.02
1921	3 819.07	17 608.09	5 218.35	5 121.34	31 766.85	770.00	30 996.85

[a] These sums represent dues paid in advance and do not include any unpaid bills except for 1920, a loan of $2200 from the Girard Trust Company.

[b] These items include $1300 on account of Life Memberships.

The surplus on December 31, 1921 was $30,996.85 and includes $1300 Life Membership Fund, $2467.17 for rent paid in advance, $2654.17 for furniture and fixtures, and $4200 set aside as a sinking fund towards defraying the cost of the 1924 issue of the Book of Standards.

The sale of Society publications has increased each year for many years. The receipts from this source for 1921 were $18,003.56 compared with $10,983.37 for the previous year. The very large increase in these receipts is due in part to the appearance in 1921 of the triennial Book of Standards. It is interesting to note that the percentage ratio of receipts from sales of publications to total receipts is steadily increasing. In 1902 when the Society was incorporated the ratio was 1.3 per cent. By 1910 it had grown to 11.5 per cent, in 1920 to 19.1 per cent, and in the past year jumped to 27.6 per cent.

Inventory of Publications in Stock.—In the foregoing financial analysis no account has been taken of the assets of the Society in the form of publications in stock. The inventory on May 15, 1922, may be summarized as follows:

	NUMBER OF COPIES.
Proceedings	7,726
1921 Book of A.S.T.M. Standards	2,890
Index (Vols. I–XII, incl.)	607
Reports of Committee D-1 (1903–1914 incl.)	312
1921 Book of A.S.T.M. Tentative Standards	39

Distribution of Translated Standards.—In BULLETIN No. 3, October 25, 1921, the Executive Committee announced that the English-French editions of sixty-one A.S.T.M. specifications had been published by the U. S. Department of Commerce in pursuance of previous agreement and that the Department was distributing copies in those countries where the translations are applicable. Certain members of the Society interested in export trade have effectively aided the Department of Commerce in making these specifications better known and more widely used abroad.

Plans are being laid for the translation of about forty of these specifications into Portuguese and the printing of an English-Portuguese edition for use in Brazil.

Through the personal interest of D. E. Douty, a member of the Executive Committee, who has been in China for the major part of a year, plans are being consummated for the sale of the Society's publications through a local publication house in Shanghai, and the Secretary-Treasurer has written to over 250 engineers and others in China who are presumed to be interested in standards for materials, pointing out the value to them of the Society's standards. In this way it is hoped to aid the industrial development of China and assist the Department of Commerce in its endeavors to extend export trade.

In order to make the Society's standards better known abroad, and available for consultation in connection with export orders, complimentary copies of the standards and tentative standards have been sent to the foreign embassies and legations at Washington and to our commercial attachés and trade commissioners in foreign countries, with an appropriate letter calling attention to the Society's activities and to the importance that its standards have assumed in this country.

Distribution of A.S.T.M. Preprints.—During the year careful consideration was given by the Executive Committee and Committee E-6 on Papers and Publications to our policy in the matter of distribution of preprints. It was decided to place before the membership several alternative plans of distribution that have been proposed at various times and this was done fully in Bulletin No. 4, January 30, 1922, in the form of a questionnaire, returns of which were canvassed in April. These returns are here summarized as a matter of record:

	VOTES.
PLAN 1.—The plan now in force, namely, mail to all members in advance of meeting all committee reports and as many papers as possible, and to distribute a complete set of reports and papers to each member attending the meeting	171
PLAN 2.—Same as at present, except that only the reports and papers not mailed in advance would be distributed at meeting	240
PLAN 3.—Mail all reports in advance; mail papers in advance only to members requesting them; and distribute complete set at meeting	51
PLAN 4.—Mail in advance of meeting only those reports and papers members have requested be sent them; and distribute complete set of reports and papers at meeting	335
Special Comments	22
Total number of returns	819

In the light of these returns and after a full discussion of the matter of policy involved, the Executive Committee has adopted Plan 4 as the future policy and will put it into effect for the annual meeting in 1923, as announced in BULLETIN No. 5. Such modifications of our present regulations as will be necessary in putting this plan into effect will be considered jointly by the Executive Committee and Committee E-5 on Standing Committees.

Distribution of Regular Publications.—There has also been considered during the year the matter of policy involved in the plan of distributing regular publications, that is, the Year Book, Book of Standards with supplements, and the annual Proceedings. Suggestions having come to the Executive Committee that, notwithstanding the fact that these are regular publications, there may be some members who may care to receive only certain of these books or certain portions of them if they were published in sections, the Executive Committee obtained an expression of opinion from the membership through the issuance of a questionnaire in Bulletin No. 4. The returns from that questionnaire, as announced in Bulletin No. 5, give overwhelming evidence of the desire of the members who replied to receive all of the regular Society publications. In answer to the question: "Do you believe the Society should adopt a policy of distributing regular publications only to those members who state their desire to receive specific ones?" 430 members answered "yes" and 357 "no." Of the affirmative votes, however, 330 members indicated that should this policy be adopted they would nevertheless desire to receive complete sets of the Society's publications. In brief, about 85 per cent of all who replied to the questionnaire indicated their wish to receive all publications of the Society whatever policy was adopted. The Executive Committee therefore voted to continue the present policy of the Society and has directed Committee E-6 on Papers and Publications to consider and report upon a plan of issuing the Book of A.S.T.M. Standards in sections or in loose-leaf binding, in such a way as to effect maximum economy in the publication of that volume and at the same time make it possible for members to secure in most convenient form those groups of standards which they especially desire.

Publication of Index of Proceedings, Vols. XIII to XX.—The circularization of the membership of the Society in BULLETIN No. 4 resulted in a sufficient number of orders to warrant the publication of an Index of the Proceedings from Vols. XIII to XX inclusive (1913–1920) on the basis that copies will be furnished at cost to members ordering them. The Executive Committee has accordingly authorized the Committee on Papers and Publications to proceed with the publication of this volume, and the endeavor will be made to issue the volume this year to members who order it.

Rotation of Annual Meetings.—The Executive Committee announced in BULLETIN No. 5 that an analysis of a questionnaire on this subject issued shortly after the last annual meeting had indicated that 305 members favored the plan of holding annual meetings in different places in succeeding years, while 182 had opposed this plan. The Executive Committee also received during the year the following resolution from Committee E-6 on Papers and Publications:

> "*Whereas,* In the formulation of the program for the annual meeting of the Society, the Committee on Papers and Publications has been confronted with the difficulty of providing for both reports of standing committees and the technical papers at the same sessions, which, together with space limitations in the Proceedings, has resulted in the committee being forced to reject papers of value; and
>
> "*Whereas,* There seems to be a feeling that the annual meetings are losing to some extent the usual interest that has characterized them in past years, by reason of the necessity of presenting both committee reports and papers under

considerable pressure as to time, with little opportunity for discussion, which lends interest to the meetings; and

"*Whereas*, The rapidly increasing number of interests of the Society are yearly adding to these difficulties; therefore, be it

"*Resolved*, That the Executive Committee of the Society be requested to give immediate and careful consideration to the plan of holding simultaneous sessions during the annual meeting; and further, that it give consideration to the desirability of holding annually two meetings of the Society, one, as usual, in June for the consideration of standards and tentative standards, and a midwinter meeting, which could be a technical session for consideration of papers on testing and research."

The complete report of a special committee to which these matters were referred was published in BULLETIN No. 5, in pursuance of which the Executive Committee has continued the special committee to make a further study of the whole matter, especially in view of the recommendation of the Committee on Papers that consideration be given to the desirability of holding two meetings of the Society a year. The Executive Committee also authorized the Committee on Papers to arrange for one or more simultaneous sessions at this annual meeting if necessary, and an examination of the program shows that it was found necessary to hold two such sessions in order to complete the business of the meeting within the allotted time.

Specifying of Patented Apparatus in Standards.—As announced in Bulletin No. 3, October 25, 1921, the Executive Committee has executed for the Society an agreement with the C. J. Tagliabue Manufacturing Co. providing for the issuance by that company of licenses, for the nominal sum of $1, to other manufacturers approved by the Executive Committee of the Society permitting them to make the Tag Closed Tester, as specified in the Society's Standard Methods of Test for Flash Point of Volatile Flammable Liquids (D 56 – 21), under certain stipulated conditions. The wording of the agreement was published in full in the BULLETIN.

Promotion of Knowledge of Engineering Materials.—It will be recalled that in its last annual report the Executive Committee stated that it had under consideration the broad problem of stimulating the study of properties of materials and was addressing itself to the question "How can research and investigation of engineering materials be stimulated in the Society?" The outcome of discussion of this subject during the year may be expressed most readily by quoting from the report of the special committee which is charged by the Executive Committee with the consideration of the subject, which report was accepted by the Executive Committee as one of progress. Certain suggestions outlined in this report have been carried out successfully this year, especially the stimulation of study of methods of testing by the various standing committees and the constructive planning of the program of the annual meeting by the Committee on Papers. The Symposium on Impact of Materials as well as several of the formal discussions that are announced on the program are directly the outcome of such constructive planning.

REPORT OF SPECIAL COMMITTEE.

"The report of this committee presented April, 1921, contained certain recommendations which were formally adopted by the Executive Committee and others which were simply received in the nature of a progress report, as asked by the committee.

"One of the things that has been accomplished is the carrying out of the suggestion that there should be brought to the attention of the standing committees, through Committee E-1, the thought that our committees should 'cultivate the field of methods of testing as intensively as they have the field of specifications.' This matter was discussed at a meeting of Committee E-1 and brought to the attention of each standing committee through a suitable circular letter. In addition, Committee E-1 has mapped out a program of study from a fundamental basis of the various methods of test in the Society, dividing them into suitable groups. Four sub-committees are now actually organized and functioning, *e. g.*, Revision of Methods of Testing; Plasticity, Consistency, etc.; Volatility; and Water in Bituminous Materials. The committee is now engaged in the study of methods of tests falling within other groups, with a view of organizing suitably representative sub-committees to review those tests in the same way.

"One of the sections of the committee's report of a year ago which was accepted as a report of progress referred to the stimulation of research and investigation of materials, first by individuals and second by committees.

"*Research by Individuals.*—There were three suggestions under this heading: (*a*) Bringing this matter to the attention of committees and members of the Society; (*b*) establishing prizes for papers presented to the Society which advanced the knowledge of materials in marked degree; and (*c*) constructive planning of the program of our meeting by the Committee on Papers.

"Regarding (*a*), this subject has been mentioned each year for several years to the committee chairmen and has resulted in our securing in the aggregate quite a few papers of value. Mention of the matter in the Bulletin has been deferred until something more substantial and definite than at present can be written about our plans in this direction.

"Item (*b*) has not yet been acted upon. The subject could be referred to the Papers Committee either with or without an expression of opinion from the Executive Committee. As suggestions, the Society might establish two prizes from its general funds, named in honor of Doctor Dudley and Doctor Marburg, the prizes to be awarded for the best paper in certain fields to be determined. For example, the Dudley prize could be given for the best paper dealing with materials used in railroads, and the Marburg prize for the best paper on a method of testing. Furthermore, it should not be particularly difficult, should we adopt this plan, of securing funds for the establishment of prizes to stimulate studies in particular fields.

"The Committee on Papers has taken hold actively of the suggestions in item (*c*). There was more constructive planning of our program this year than ever before. Discussions are being arranged for such subjects as Coal Specifications, Inspection of Concrete, Fatigue of Metals, Tests of Steel Castings and Impact Testing. An effort is being made to emphasize the technical papers rather than the standards at this meeting, particularly because of the fact that last year standards had to be emphasized in view of the forthcoming 1921 Book of Standards. While it is true that some of the investigations to be described have been and will be immediately applied to standardization work (*e. g.*, the work on steel castings), some of the others, such as fatigue of metals and impact testing, are being developed purely to advance knowledge of materials without regard to standardization.

"*Research by Committees.*—In the report of a year ago the committee suggested certain questions. The general consensus of opinion was that we should move slowly in the matter of creating separate standing committees of the Society to deal with problems of research *per se.* It was felt that where existing committees were able to do such work effectively, they should be used, and that the consideration of organization of research committees (probably of limited membership) to study the properties of materials should be undertaken only where there is a very evident demand for such committees. There was also discussed at that time our relationship to research through our representation on the Engineering Division of the National Research Council, and it was recognized as advantageous that the Executive Committee is constituted as an advisory committee on research of engineering materials to the Engineering Division. The one specific instance that came up during the year touching upon our relationship to the National Research Council is the work of their Committee on Hardness Testing of Metals. It is the thought of the committee that this Research Committee on Hardness Testing of Metals has a field which lies for the most part within that of our Society and that we should in some suitable way act as a sponsor for the work of the committee.

"The committee also points out that the Symposium on Impact Testing being arranged by the Committee on Papers may perhaps bring out the desirability of studying, through some committee, the real significance of the impact test and the property or properties of materials that are developed by that test.

"Briefly, then, the committee has to report that certain definite suggestions have been put into effect and that it is waiting developments in these directions before undertaking anything more extensive. It seems evident that the development of research in the A.S.T.M. to promote knowledge of materials *per se* must be a matter of growth just as our present machinery for the production of standards has grown from the organization of the Society over twenty years ago. In submitting this report of progress during the year the committee would request that it be continued with such instructions that the Exec mittee may wish to give.

"Respectfully submitted by the committee,

G. AERTSEN,
E. D. BOYER,
G. K. BURGESS,
D. E. DOUTY,
C. L. WARWICK, *Chairman.*"

American Engineering Standards Committee.—Past-President J. A. Capp has been reappointed for three years as one of the Society's representatives on the Standards Committee. The death of Past-President A. W. Gibbs creates a vacancy in our representation which will be filled by appointment during the annual meeting.

Members of the Society have been kept acquainted through various issues of the Bulletin with the activities of the Society and its committees in relation to the work of the American Engineering Standards Committee. Accordingly it will be necessary in this report only to mention as a matter of official record certain happenings during the year and to refer to cooperative relations that are in course of development which involve the Society's relations with the Standards Committee and the U. S. Department of Commerce.

The Standard Specifications and Tests for Portland Cement (C 9 – 21) have been formally approved by the Standards Committee as "American Standard" and the Society has been designated as the sponsor for this standard. This is the first of our standards, and incidentally the first specification for a material, that has received this official designation.

The following thirteen Society standards have been formally approved as "Tentative American Standard":

Standard Specifications for:

- Fire Tests of Materials and Construction (C 19 – 18);
- Drain Tile (C 4 – 21);
- Soft or Annealed Copper Wire (B 3 – 15);
- Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 4 – 13);
- Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 5 – 13);
- Cold-Drawn Bessemer Steel Automatic Screw Stock (A 32 – 14);
- Cold-Drawn Open-Hearth Steel Automatic Screw Stock (A 54 – 15).

Standard Methods of:

- Test for Toughness of Rock (D 3 – 18);
- Test for Softening Point of Bituminous Materials Suitable for Road Treatment (D 20 – 18);
- Sampling Coal (D 21 – 16);
- Battery Assay of Copper (B 34 – 20);
- Chemical Analysis of Manganese Bronze (B 27 – 19);
- Chemical Analysis of Gun Metal (B 28 – 19).

The Society has been designated as sponsor for Methods of Chemical Analysis of Manganese Bronze and of Gun Metal, and joint sponsor with the Department of Agriculture for the Drain Tile Specifications.

The following ten standards have also been submitted for approval as Tentative American Standard and are now receiving consideration:

Standard Specifications for:

- Carbon-Steel and Alloy-Steel Forgings (A 18 – 21);
- Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19 – 21);
- Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 63 – 21);
- Carbon-Steel Forgings for Locomotives (A 20 – 21);
- Carbon-Steel Car and Tender Axles (A 21 – 18).
- Purity of Raw Linseed Oil from North American Seed (D 1 – 15);
- Purity of Boiled Linseed Oil from North American Seed (D 11 – 15).

Standard Methods of:

- Test for Penetration of Bituminous Materials (D 5 – 21);
- Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (B 18 – 21);
- Laboratory Sampling and Analysis of Coke (D 37 – 21).

Some fifteen additional standards have been recommended by the standing committees concerned to the Executive Committee for submission in this way to the Standards Committee.

The Society has been designated as joint sponsor with other organizations for the following standardization projects relating to engineering materials:

With the American Zinc Institute, the Society is sponsor for a Sectional Committee on Zinc and Zinc Ores, whose organization was mentioned in the last annual report. The work of this sectional Committee is well under way and has been closely coordinated with that of our Committee B-2 on Non-Ferrous Metals and Alloys.

With nine other national organizations, the Society is joint sponsor for the Sectional Committee on Insulated Wire and Cables for Other Than Telephone and Telegraph Use. This Sectional Committee was formally organized in January, 1922, the Society's representatives being W. H. Bassett and F. M. Farmer. The Society has taken an active part in the development of this Sectional Committee. Two of its sub-committees, on Copper Conductors and on Rubber Insulation, are under the chairmanship respectively of J. A. Capp, Chairman of the Society's Committee B-1 on Copper Wire, and F. M. Farmer, Chairman of Committee D-11 on Rubber Products, thus insuring absolute coordination of work on these materials. Other committees of the Society who have under consideration materials used in the construction of wire and cable are Committees B-2 on Non-Ferrous Metals and Alloys and D-9 on Electrical Insulating Materials, and these committees are also represented on the various sub-committees of the Sectional Committee. Coincident with the organization of this Sectional Committee, the Society was invited to take over the work of the Joint Rubber Insulation Committee which had formulated the procedure for analysis of rubber compound. This invitation has been accepted and the development of the matter placed in the hands of our Committee D-11, as previously announced in BULLETIN No. 3.

The U. S. Forest Service and the Society have been designated as joint sponsors for the development of Methods of Testing Wood, and the organization of a Sectional Committee on this subject is in process.

The Society is also represented on the following Sectional Committees under the sponsorship of other organizations:

Sectional Committee on Tie Specifications under the sponsorship of the American Railway Engineering Association and the Forest Service, represented by A. L. Kuehn, with H. P. Hass as alternate.

Sectional Committee on Conductivity of Aluminum under the sponsorship of the American Institute of Electrical Engineers, represented by J. M. Darke.

Sectional Committee on Aeronautical Safety Code under the sponsorship of the U. S. Bureau of Standards and the Society of Automotive Engineers, represented by the Secretary-Treasurer.

The Executive Committee is giving consideration to the matter of cooperation with the Sectional Committee on Standardization of Shafting inasmuch as certain questions have arisen that make it desirable for Committee A-1 on Steel to prepare specifications for the quality of shafting which will involve the matter of tolerances, a subject that is also being considered by the above mentioned Sectional Committee.

The members of the Society are probably familiar through notices in the technical and daily press of the organization by Secretary of Commerce Hoover in the Department of Commerce of a Division of Simplified Practice for the purpose of aiding the industries of the country in the elimination of waste, notably through the simplification of practice such as reduction of number of varieties and sizes of manufactured products. A notable instance of an effort in this direction is the agreement between the producers and users to reduce variety and sizes of vitrified paving brick as an outcome of a conference, at which the Society was duly represented and concerning which our Committee C-3 on Brick is making recommendations at this annual meeting. Announcement of this conference was made in a recent issue of the BULLETIN.

In some respects the activities of the Division of Simplified Practice are closely related to the aims and objects of the American

Engineering Standards Committee, in which are represented the leading engineering organizations of the country and many large industrial organizations whose activities are closely related to engineering. Conferences between the Standards Committee and the Division of Simplified Practice have led to the formulation of plans for cooperation by which the Standards Committee will be represented on the Division by Past-President A. A. Stevenson, who is one of the Society's representatives on the Standards Committee. It is the understanding of the Executive Committee that in the further development of this plan for simplifying practice in the industries, the Department of Commerce will look to the American Engineering Standards Committee to see that the engineering and allied technical organizations of the country are properly represented.

Since the work that will be undertaken jointly by the Standards Committee and the Division of Simplified Practice will frequently be of immediate concern to A.S.T.M. committees, the Executive Committee has been interested in the formulation of the plans for cooperation to the end that our committees may be given an opportunity to be represented at any of these simplification conferences that touch their activities. Accordingly suitable communications have been addressed to the Standards Committee and to the Secretary of Commerce stating that the Society is entirely in sympathy with the means that have been taken to bring about closer cooperation between the Standards Committee and the Department of Commerce and expressing our desire that our various standing committees shall be directly represented at such conferences as concern them. In view of the importance of this subject, the Executive Committee has addressed a letter of explanation to the officers of all standing committees.

Building Code Committee of the Department of Commerce.—Upon invitation of the Secretary of Commerce, the Society has been cooperating with the Building Code Committee appointed by the Department of Commerce to define some of the needless variations and disagreements in building codes and to suggest amendments. A complete set of the Society's standards and tentative standards was furnished to the committee. A tentative report of the committee on the subject "Recommended Minimum Requirements for Small House Construction," issued in limited edition for criticism, recommends the use of many of the Society's standards for materials, and at the request of the committee the report has been referred to the committees of the Society interested for criticism and comment.

Cooperation with Federal Specifications Board.—The Executive Committee has noted with interest the organization of the Federal

Specifications Board for the purpose of harmonizing the wide variety of specifications used in the several Government departments, and has formally expressed to the Board the willingness of the Society to cooperate in whatever way is possible in the field of the Society's activities. The means established by the Federal Specifications Board for cooperation with non-Government bodies is through the formation of advisory committees, upon two of which the Society is now represented by invitation, namely, Committee on Standardization of Petroleum Specifications, by T. G. Delbridge, and the Committee on Refractories, by W. H. Fulweiler.

Division of Engineering, National Research Council.—Recent issues of the BULLETIN have carried mention of current happenings in the relations of the Society with the Engineering Division of the National Research Council. Subjects with which we have been in touch include the work of the Advisory Committee on Highway Research, the work of the Division's Committee on Corrosion, upon which W. H. Bassett and D. M. Buck have been appointed as Society representatives, and the work of the Division's Committee on Hardness Testing of Metals.

During the year certain activities of the American Bureau of Welding, which is one of the Advisory Boards of the Division of Engineering, have been of particular interest to our Society, especially those relating to the work of committees of the Bureau on Specifications for Steel to be Welded and Specifications for Welding Wire. E. F. Kenney and H. L. Whittemore have been appointed to represent Committee A-1 on Steel on the former committee, and Mr. Whittemore to represent Committee A-1 on the latter committee. Expecially in the case of the former committee has it seemed to be most desirable to prevent any duplication of work and to keep the Bureau of Welding in close touch with the specification work of our own committee.

On invitation from the Joint Molding Sand Research Committee, which was organized under the sponsorship of the Engineering Division of the National Research Council and the American Foundrymen's Association, Vice-President G. K. Burgess, Past-President G. H. Clamer and Richard Moldenke have been appointed to represent the Society on that joint committee, especially to aid in the formulation of tests for molding sand.

Cooperation with A.S.M.E. Boiler Code Committee.—Cooperation with the American Society of Mechanical Engineers in the matter of specifications for materials included in the Boiler Code of that Society has been actively continued throughout the year. In the revision of the Boiler Code that is being undertaken by the Society of Mechanical Engineers, the standards of the Society for materials are being used as the basis for Boiler Code requirements. A conference of duly authorized representatives of the two societies has resulted in agreement on nearly all points of difference that were found between the Society's standards and those of the Boiler Code and these several points are under discussion now in the appropriate committees of the two societies. The heartiest spirit of cooperation has been evidenced throughout in this important work, to the end that the Boiler Code will be as nearly as possible in accord, in so far as materials specifications are concerned, with A.S.T.M. standards.

Miscellaneous Joint Committees.—The Society has continued during the past year its participation in the work of the several joint committees upon which it has appointed representatives, as follows:

The Joint Committee on Investigation of Phosphorus and Sulfur in Steel has completed the first problem undertaken, the study of the effect of sulfur in rivet steel, and has prepared a preliminary report which will be presented at this annual meeting. The investigation of the effect of sulfur in structural steels and in forging steels is well advanced.

The Joint Committee on Specifications for Steel Castings for Railways consisting of representatives of the Society and the American Railway Association, Mechanical Division, after investigation extending over two years, has presented a report to the constituent societies, which is being transmitted to the Society at this annual meeting by Committee A-1 on Steel. The report embodies proposed Tentative Specifications for Steel Castings for Railroads.

A report of progress will be presented at this meeting by our representatives on the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. The committee has carefully considered all criticisms of its progress report submitted a year ago and is awaiting the result of certain important investigations before proceeding with the preparation of a report embodying final recommendations regarding specifications.

The Society's representatives on the Joint Committee on Concrete Culvert Pipe will present at this meeting a report of substantial progress of the work of this committee.

Progress has been reported in the BULLETIN in the matter of pattern standardization, which is in charge of a Joint Committee on Standard Pattern Practice organized under the sponsorship of the American Foundrymen's Association.

Upon joint invitation of the U. S. Bureau of Standards and the U. S. Bureau of Mines, the Society has appointed J. A. Mathews as its representative in an investigation on breakage and heat treatment of rock drill steels. Vice-President G. K. Burgess has been appointed as our representative on an informal Committee on Gage Steel, organized at the suggestion of the Ordnance Department, U. S. A. D. L. Quinn has been appointed from Committee D-10 on Shipping Containers to represent the Society on a committee that has been formed by the Bureau of Explosives at the request of the American Railway Association to make an investigation, from an engineering standpoint, of shipping containers.

Other Cooperative Work.—Among other cooperative work of the Society that has been formally instituted this year may be mentioned the following:

Committee D-5 on Coal is cooperating with the American Chemical Society, American Gas Association, National Association of Purchasing Agents, American Mining Congress, and the American Society of Mechanical Engineers in various phases of its activities. Committee B-1 on Copper Wire is cooperating with a similar committee of the American Electric Railway Association in an endeavor to harmonize the specifications of the two bodies for trolley wire. Close relations have been established between our Society and the Society of Automotive Engineers in the matter of steel specifications through the appointment of F. P. Gilligan as a representative of the S.A.E. Iron and Steel Division on Sub-Committee X on Automobile Steels of Committee A-1, and Albert Ladd Colby as a representative of Sub-Committee X on the Iron and Steel Division; also through the appointment of W. C. Peterson as a representative of the S.A.E. Iron and Steel Division on Sub-Committee XIX on Sheet Steel and Steel Sheets of Committee A-1, and G. M. Williams as a representative of Sub-Committee XIX on the Iron and Steel Division. The Society was also invited to name a representative on the Lubrication Division of the Society of Automotive Engineers and has appointed K. G. Mackenzie, Secretary of Committee D-2 on Petroleum Products and Lubricants, as the representative.

Cooperation between Committee D-2 on Petroleum Products and Lubricants and the Institute of Petroleum Technologists of Great Britain has been provided for through the appointment of a representative of that Institute on our committee. It is hoped in this way to further international relations in this important field. Committee D-2 has also established cooperative relations with the American Gas Association in the consideration of specifications for gas absorbent oils.

Cooperation of many of our committees with appropriate committees of the American Society for Municipal Improvements and the American Ceramic Society has been facilitated by the election of those societies to membership in our Society and the appointment of their representatives upon those of our committees in whose work they are particularly interested. These appointments should be of considerable mutual benefit and it is hoped will lead to adoption of uniform standards in the several societies.

The Society is represented on two committees that are advisory to the Bureau of Standards, one covering the field of non-ferrous metals and alloys and the other the field of ferrous metals. The Society's representatives on the former are William Campbell, W. R. Webster, G. H. Clamer, W. H. Bassett and N. K. B. Patch. On the latter the representatives recently appointed are J. H. Parker and H. T. Morris.

Respectfully submitted on behalf of the Executive Committee,

C. D. YOUNG,
President.

C. L. WARWICK,
Secretary-Treasurer.

REPORT OF COMMITTEE A-1
ON
STEEL.

During the past year, Committee A-1 has held three meetings, one on October 7, 1921, the second on March 3, 1922, and the third on April 21, 1922. A fourth meeting will be held prior to the presentation of this report to the Society, at which the report will be briefly reviewed and other matters considered.

The Advisory Committee has held four meetings, at which matters concerning the general administrative affairs of the committee were considered.

The present membership of the committee is 142, of which 78 are classed as non-producers and 64 as producers.

Sub-Committees.—One new sub-committee has been appointed during the year: Sub-Committee XIX on Sheet Steels.

The committee has also appointed representatives on sub-committees of the American Bureau of Welding and the Society of Automotive Engineers.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS.

The recommendations of the committee affecting standards and tentative standards are presented first in summarized form together with an analysis of the letter ballot on each item. They are then referred to where necessary in greater detail, being grouped for convenience in the order of the respective sub-committee directly responsible for them.

I. Proposed Revisions in Standards.—The committee recommends that the revisions in the following standards, which are given in full in Appendix I to this report, be published as tentative for one year before referring them to letter ballot of the Society for adoption as standard:

1. For Steel Track Spikes (A 65 - 18).
2. For Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 - 21).
3. For Welded and Seamless Steel Pipe (A 53 - 21).
4. For Automobile Carbon and Alloy Steels (A 29 - 21).
5. Standard Methods of Chemical Analysis of Plain Carbon Steel (A 33 - 14).

6. Standard Methods of Chemical Analysis of Alloy Steels (A 55 – 15).

II. Proposed New Tentative Standard.—The committee recommends that the following new specifications, which are appended to this report,[1] be accepted for publication as tentative:

7. For Carbon-Steel Castings for Railroads.

III. Tentative Standards.—The committee recommends that the following tentative standards remain as tentative for another year:

For Steel Tie Plates (A 67 – 20 T).
For Boiler and Firebox Steel for Stationary Service (A 70 – 21 T).
For Carbon Tool Steel (A 71 – 21 T).
For Low-Carbon-Steel Track Bolts (A 76 – 20 T).
For Electric Cast Steel Anchor Chain (A 77 – 20 T).
For Steel Plates for Forge Welding (A 78 – 21 T).
For Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 21 T).
For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 21 T).

The above recommendations have been referred to letter ballot of the committee, which consists of 142 members: 109 ballots have been cast, 33 members having refrained from voting. The analysis of the vote of the committee is given in the following table:

Items.	Affirmative.	Negative.	Not Voting.[a]
I. PROPOSED REVISIONS IN STANDARDS.			
1. For Steel Track Spikes (A 65 – 18)	57	1	44
2. For Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 21)	56	3	43
3. For Welded and Seamless Steel Pipe (A 53 – 21)	61	0	41
4. For Automobile Carbon and Alloy Steels (A 29 – 21)	55	0	47
5. Standard Methods of Chemical Analysis of Plain Carbon Steel (A 33 – 14)	77	0	31
6. Standard Methods of Chemical Analysis of Alloy Steels (A 55 – 15)	77	0	31
II. PROPOSED NEW TENTATIVE STANDARD.			
7. For Carbon-Steel Castings for Railroads	76	2	31

Total number of ballots cast	109
Number of members who failed to vote	33
Total membership	142

[a] In this column is recorded the number of votes cast as "Not Voting" on the various items.

SUBMISSION OF SPECIFICATIONS TO THE AMERICAN ENGINEERING STANDARDS COMMITTEE.

In accordance with action taken at the meeting held on March 3, 1922, the following specifications have been approved for submission to the Secretary-Treasurer for transmission to the American Engineering Standards Committee:

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[1] See p. 560.—ED.

A 7 – 21 Structural Steel for Bridges.
A 8 – 21 Structural Nickel Steel.
A 9 – 21 Structural Steel for Buildings.
A 10 – 21 Structural Steel for Locomotives.
A 11 – 21 Structural Steel for Cars.
A 12 – 21 Structural Steel for Ships.
A 13 – 21 Rivet Steel for Ships.
A 14 – 16 Carbon-Steel Bars for Railway Springs.
A 61 – 16 Helical Steel Springs for Railways.
A 62 – 16 Elliptical Steel Springs for Railways.
A 53 – 21 Welded and Seamless Steel Pipe.

In the following the committee presents the foregoing recommendations in detail where necessary, as well as other features of its work, grouped for convenience in the order of the respective sub-committees responsible for them.

STEEL RAILS AND ACCESSORIES (SUB-COMMITTEE I).

This sub-committee has been giving consideration to the rail specifications but is not prepared to recommend any changes at this time. The proposed change in the requirements of Section 6 on Workmanship of the Standard Specifications for Track Spikes (A 65 – 18) is submitted for approval.

STRUCTURAL STEEL FOR BRIDGES, BUILDINGS AND ROLLING STOCK (SUB-COMMITTEE II).

Sub-Committee II has been working on suggested revisions of the table of permissible overweight for plates ordered to thickness in all specifications under its jurisdiction, but is not yet prepared to make any definite recommendations for revisions.

STEEL REINFORCEMENT BARS (SUB-COMMITTEE V).

This sub-committee has arranged to be represented by Messrs. C. F. W. Rys and E. E. Hughes on the special committee which has been formed by the Society to investigate deformed bars for concrete reinforcement.

STEEL TUBING AND PIPE (SUB-COMMITTEE IX).

Sub-Committee IX has reviewed the specifications under its charge and is recommending a change in the title of the table in the Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 21), and a revision of Section 14 (*c*) of the Standard Specifications for Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 21), both of these changes being for the purpose of clarifying the meaning of the sections affected.

AUTOMOBILE STEELS (SUB-COMMITTEE X).

This sub-committee has reviewed the Standard Specifications for Automobile Carbon and Alloy Steels (A 29 – 21) and recommends certain revisions in order to harmonize them with the specifications of the Society of Automotive Engineers.

BOILER STEEL (SUB-COMMITTEE XI).

This sub-committee has under consideration the question of revising the table of permissible tolerances for overweight in plates ordered to thickness as well as other matters affecting its specifications, and is in close connection with the Boiler Code Committee of the American Society of Mechanical Engineers through the Conference Committee appointed by the Society for that purpose.

METHODS OF CHEMICAL ANALYSIS (SUB-COMMITTEE XII).

Sub-Committee XII has completed the work of revising the Standard Methods of Chemical Analysis of Plain Carbon Steel (A 33 – 14) and of Alloy Steels (A 55 – 15) and submits these for approval as tentative standards.

The chief changes in the Standard Methods of Chemical Analysis of Plain Carbon Steel comprise:

1. The addition of an optional method of direct weighing of the carbon dioxide obtained in direct combustion, and the omission of the colorimetric method.
2. The addition of an optional ferrous sulfate titration in the absence of high chromium in the bismuthate method for manganese.
3. The omission of the colorimetric method for manganese.
4. The precipitation of barium sulfate in a reduced iron solution in the oxidation method for sulfur.
5. The optional precipitation of copper by sodium thiosulfate.
6. The transferring of the description of methods of analyses for nickel and chromium to the proper alloy steels.

The chief changes in the methods of chemical analysis of alloy steels comprise:

1. The placing of the description of the gravimetric method for

the determination of nickel under the heading of nickel steel and allowing three optional methods of preparing the solution for the routine cyanide titration.

2. The omission of the zinc oxide-bismuthate method for manganese in chrome-nickel steel and the substitution of the hydrolysis-bismuthate method.

3. The omission of the modified routine bismuthate method for manganese in chrome-nickel steel and the substitution of the persulfate method.

4. The omission of the fusion method for chromium in chrome-nickel steel and the substitution of the persulfate oxidation method.

5. The omission of the chlorate and the permanganate oxidation methods for the determination of chromium in chrome-nickel steel.

6. The omission of the methods for analysis of vanadium steel and the inclusion of these methods with chrome-vanadium steel.

7. The omission of the phosphomolybdate-precipitation and ether extraction-hydrochloric acid reduction methods for the determination of vanadium in vanadium steel and the substitution of the electrolytic separation and the routine reduction with ferrous sulfate and titration with permanganate methods.

8. The omission of the fusion and chlorate methods for chromium in chrome-vanadium steel and the substitution of the persulfate oxidation method.

9. The condensing of directions for the analysis of silico-manganese steel in one paragraph, referring to the Standard Methods of Chemical Analysis of Plain Carbon Steel.

10. The addition of methods of analysis of tungsten and of molybdenum steel.

The ladle test ingot investigation has been completed and the report of the sub-committee received by Committee A-1.

TOOL STEEL (SUB-COMMITTEE XIV).

This sub-committee has under review the Tentative Specifications for Carbon Tool Steel (A 71 – 21 T) and also has a sub-sub-committee at work on specifications for high-speed tool steel.

COMMERCIAL BAR STEELS (SUB-COMMITTEE XV).

This sub-committee has been instructed to consider the preparation of specifications for cold-finished shafting, providing for physical characteristics of the material and tolerances.

LITERARY FORM (SUB-COMMITTEE XVII).

This sub-committee considered the question of the proper order of reporting chemical elements and physical properties of steel. This subject was referred to Committee A-1 by Committee A-4, and the work of the sub-committee making certain definite recommendations both as to the order of reporting chemical elements and physical properties and abbreviations for those properties has been forwarded to the chairman of Committee A-4 with the recommendation that the suggestions made be approved and brought to the attention of Committee E-5 on Standing Committees.

SHEET STEELS (SUB-COMMITTEE XIX).

This sub-committee has effected an organization and commenced its work by appointing sub-sub-committees on Automobile Steel Sheets, Galvanized Roofing Sheets, Cold-Rolled Strip Steel, and Nomenclature and Definitions.

JOINT COMMITTEE ON STEEL CASTINGS FOR RAILROADS.

The organization of this Joint Committee was given in the report of Committee A-1 in 1920, and the membership consists of representatives of the American Society for Testing Materials and the American Railway Association, Mechanical Division. This Joint Committee has prepared proposed Tentative Specifications for Steel Castings for Railroads, which was reported by the A.S.T.M. representatives to Committee A-1 at a special meeting held on April 21, 1922. This report is given in Appendix II. The specifications were modified at the meeting of Committee A-1, the modifications consisting for the most part in changes of form. There was one change in substance, however, in Section 4 (*b*) of the specifications, the first sentence being changed from its present form: namely,

> "For the purpose of determining the quality of annealing, at least two and not more than four annealing lugs shall be cast on all castings 150 lb. or over and on such castings less than 150 lb. as required by the purchaser or his representative."

to read as follows:

> "For the purpose of determining the quality of annealing of all castings weighing 150 lb. or over, and of such lighter castings as shall be required by the purchaser or his representative, there shall be provided for removal by the inspector after annealing and also after reannealing, if necessary, at least one and not more than two annealing lugs."

The specifications as modified by action of Committee A-1 are submitted as appended hereto[1] for approval for publication as tentative.

The Joint Committee reported that they had experienced considerable difficulty in harmonizing the ideas of consumers and producers but that the specifications recommended represent the best agreement that it was possible to secure, and the vote of the Joint Committee itself on these specifications was 27 in favor, none opposed, 2 not voting. Total membership 29.

The American Railway Association Committee on Specifications and Tests has presented the proposed specifications as a part of its 1922 report to the Association, and it has been accepted to be printed as information.

In the opinion of Committee A-1 it is desirable for the Society to print these specifications as a tentative standard so that they may be brought before the public and the opportunity given for comment and criticism which will unquestionably lead to further changes and, it is hoped, eventual approval and adoption by the railroads.

Committee A-1 approves the recommendations of Committee A-2 on Wrought Iron for revisions of the Tentative Specifications A 83 - 21 T.

This report has been submitted to letter ballot of the committee, which consists of 142 members, of whom 100 have voted affirmatively, 2 negatively, and 40 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. WARING,
Chairman and Temporary Secretary.

EDITORIAL NOTE.

The proposed revisions of the four standard specifications listed in this report as items 1 to 4 on page 71 were accepted for publication as tentative and appear on page 981.

The proposed revisions of the Standard Methods of Chemical Analysis of Plain Carbon Steel and of the Standard Methods of Chemical Analysis of Alloy Steels were accepted for publication as new tentative methods and appear on pages 578 and 600, respectively.

The proposed Tentative Specifications for Carbon Steel Castings for Railroads were accepted for publication as tentative and appear on page 560.

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[1] See p. 560.—ED.

APPENDIX I.

PROPOSED REVISIONS IN STANDARDS FOR STEEL.

In this appendix are given proposed revisions in certain standard and tentative specifications, which, for convenience, are numbered from 1 to 6, inclusive, to correspond to the report of the committee. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

PROPOSED REVISIONS IN STANDARDS.

No. 1.—Standard Specifications for Steel Track Spikes: A 65 - 18.[1]

Section 6.—Change to read as follows:

"The spikes shall conform to the dimensions specified by the purchaser except that a variation of $\frac{1}{32}$ in. over and $\frac{1}{64}$ in. under the specified dimension of the body of the spike, and a variation of $\frac{1}{8}$ in. over and $\frac{1}{16}$ in. under the specified dimension of the head of the spike will be permitted. A variation of $\frac{1}{4}$ in. over and nothing under the specified length of the spike, measured from the under side of the head to the point, will be permitted. A variation of 1 deg. in the specified angle of the under side of the head of the spike will be permitted."

No. 2.—Standard Specifications for Lap-Welded and Seamless Steel Boiler Tubes for Locomotives: A 28 - 21.[1]

Section 14 (c).—Divide this section into two separate paragraphs (*c*) and (*d*) as follows, relettering Paragraph (*d*) to Paragraph (*e*):

"(*c*) The thickness of hot-finished tubes at any point shall not exceed two gages above or one gage below that specified, but in all cases the weight variation shall be within that specified in Paragraph 13 (*b*).

"(*d*) In the case of boiler tubes that are expanded and swaged, the thickness of the expanded end may be $1\frac{1}{2}$ gages lighter and the swaged end three gages heavier than the thickness specified."

No. 3.—Standard Specifications for Welded and Seamless Steel Pipe: A 53 - 21.[1]

Tables I and II.—Omit the words "Black and Galvanized" now appearing under the titles of these tables.

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[1] 1921 Book of A.S.T.M. Standards.

No. 4.—Standard Specifications for Automobile Carbon and Alloy Steels: A 29 – 21.[1]

Table I.—Add to the present table the five following compositions.

Carbon.		Manganese.		Phosphorus.	Sulfur.
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.045	0.05
0.30	0.25 - 0.35	0.65	0.50 - 0.80	"	"
0.40	0.35 - 0.45	0.65	0.50 - 0.80	"	"
0.46	0.40 - 0.50	0.40	0.30 - 0.50	"	"
0.50	0.45 - 0.55	0.65	0.50 - 0.80	"	"

Table II.—In the steel of 0.15 per cent carbon, change the manganese requirement from 0.65 per cent desired (permissible range 0.50–0.80 per cent) to 0.45 per cent desired (permissible range 0.30–0.60 per cent).

Add to the present table the following composition:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.	
Desired	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.
0.50	0.45 - 0.55	0.65	0.50 - 0.80	0.04	0.045	3.50	3.25 - 3.75

Table III. (*With 1.25 per cent Nickel*).—In the steel of 0.20 per cent carbon, change the manganese from 0.65 per cent desired (permissible range 0.50–0.80 per cent) to 0.45 per cent desired (permissible range 0.30–0.60 per cent).

Add to the present table the following composition:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over.	Not Over.	Desired.	Permissible Range.	Desired.	Permissible Range.
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.04	0.04	1.25	1.00 - 1.50	0.60	0.45 - 0.75

Table III. (*With 1.75 per cent Nickel*).—Add to the present table, the two following compositions:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over.	Not Over.	Desired.	Permissible Range.	Desired.	Permissible Range.
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.04	0.04	1.75	1.50 - 2.00	1.10	0.90 - 1.25
0.45	0.40 - 0.50	0.45	0.30 - 0.60	0.04	0.04	1.75	1.50 - 2.00	1.10	0.90 - 1.25

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[1] 1921 Book of A.S.T.M. Standards.

Table III. (*With 3.50 per cent Nickel*).—Omit the compositions appearing under the heading "With 3.50 per cent Nickel" and insert the following compositions:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over.	Not Over.	Desired.	Permissible Range.	Desired.	Permissible Range.
0.12	Max., 0.17	0.45	0.30 - 0.60	0.04	0.04	3.50	3.25 - 3.75	1.50	1.25 - 1.75
0.25	0.20 - 0.30	"	"	"	"	"	"	"	"
0.35	0.30 - 0.40	"	"	"	"	"	"	"	"
0.40	0.35 - 0.45	"	"	"	"	"	"	"	"

Table IV.—Omit the present compositions and insert the following:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over.	Not Over.	Desired.	Permissible Range.
0.20	0.15 - 0.25	0.45	0.30 - 0.60	0.04	0.045	0.75	0.60 - 0.90
0.40	0.35 - 0.45	0.65	0.50 - 0.80	0.04	0.045	0.95	0.80 - 1.10
0.50	0.45 - 0.55	0.65	0.50 - 0.80	0.04	0.045	0.95	0.80 - 1.10
1.00	0.95 - 1.10	0.35	0.20 - 0.50	0.03	0.030	1.35	1.20 - 1.50

Omit the present footnote (*a*) as appearing under Table IV.

Table VII.—Omit the present compositions and insert the following:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Silicon.	
Desired	Permissible Range.	Desired	Permissible Range.	Not Over	Not Over	Desired	Permissible Range.
0.50	0.45 - 0.55	0.75	0.60 - 0.90	0.045[a]	0.045	2.00	1.80 - 2.20
0.60	0.55 - 0.65	"	"	"	"	"	"

[a] Steels made by the acid process may contain 0.05 maximum phosphorus.

NO. 5.—STANDARD METHODS OF CHEMICAL ANALYSIS OF PLAIN CARBON STEEL: A 33 - 14.[1]

These methods have been extensively revised and are appended hereto in their revised form.[2]

NO. 6.—STANDARD METHODS OF CHEMICAL ANALYSIS OF ALLOY STEELS: A 55 - 15.[1]

These methods have been extensively revised and are appended hereto in their revised form.[3]

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 578.—ED.

[3] See p. 600.—ED.

APPENDIX II.

REPORT OF THE SOCIETY REPRESENTATIVES ON THE JOINT COMMITTEE ON SPECIFICATIONS FOR STEEL CASTINGS FOR RAILROADS.

Mr. F. M. Waring, *Chairman*,
Committee A-1 on Steel.

Your representatives on the Joint Committee of the American Railway Association and American Society for Testing Materials for the preparation of Specifications for Steel Castings for Railroads submit herewith for your approval the final draft of proposed specifications, as agreed upon March 24, 1922.

In the appendix to this report an outline of the activities of the Joint Committee and its sub-committee is given as a matter of record.

Little, if any, differences of opinion were encountered on the general clauses of the specifications; the main arguments have been on the chemical and physical requirements. At the beginning of the work (1920) foundry conditions of fuel and scrap supply seemed to warrant allowing a maximum of 0.06 per cent sulfur and the committee so agreed, but in view of the improvement in such conditions the sulfur limit has been retained at 0.05 per cent and the phosphorus limit set at the same figure.

It is believed that the manganese requirement of maximum 0.85 per cent is sufficiently high to cause no trouble to the manufacturer, who would try to avoid such a content for his own protection, and at the same time protects the consumer. Some consumers expressed the opinion that the manganese requirement might be omitted altogether, to which view the manufacturers were naturally agreed, but the majority of the consumers preferred to have an upper limit specified.

The discussions on physical properties centered largely around the proposal from the A.R.A. Car Construction Committee that the elastic limit or yield point should be taken as a base and the elongation in 2 in. times the elastic limit or yield point should not fall below certain suggested constants. The sub-committee spent a great deal of time on this subject, tests were made by some of the members to develop methods for determining elastic limit and yield point and also to determine which of these properties could be considered the most accurate and satisfactory from the standpoint of the commercial laboratory. It was finally agreed upon by the majority that the yield point by drop of beam or by dividers gave the most uniform results. The determination of the so-called elastic limit was influenced by the refinement of apparatus used and the results obtained by the same method on the same grade of steel frequently showed large variations that were difficult to account for satisfactorily.

No agreement could be reached regarding the expression of ductility requirements, elongation and reduction of area, in terms of elastic limit or yield point. This form has never been used in generally accepted specifications, nor has the idea that such an expression gives a quality rating of the steel met with general acceptance. On the contrary, it is believed that the elongation bears a closer relation to the tensile strength than to the elastic limit, and certain recent fatigue tests of various grades of forged or rolled steel have appeared to indicate that resistance to fatigue failure is more in relation to tensile strength than to elastic limit. It is not unreasonable to conclude that such a relation would apply to cast steel also. This committee has therefore recommended that the ductility requirements be based on the usual formula of a constant divided by the tensile strength and has set minimum limits high enough to secure excellent physical properties when considered in connection with the minimum yield points specified.

While the action taken has not been unanimous in all cases, the negative side has been small, and motions that met with substantial opposition were reconsidered and amended until substantially unanimous approval could be secured.

Your representatives recommend that the attached specifications be accepted and be sent to letter ballot of the proper committee so that they may be included in that committee's report of 1922 to its Association or Society as a tentative standard.

The specifications have been submitted to letter ballot of the members of the Joint Committee with the result that 27 have voted in favor, none negatively and two not voting. Total 29.

Respectfully submitted,

J. C. DAVIS,
Chairman, A.S.T.M. Representatives.

REPORT OF THE JOINT COMMITTEE ON SPECIFICATIONS FOR STEEL CASTINGS FOR RAILROADS

1. The Joint Committee on Specifications for Steel Castings for Railroads was organized as a result of action by the executive boards of the American Society for Testing Materials, the Mechanical Section (now Division) of the American Railway Association, and the United States Railroad Administration, in pursuance of an agreement to work together wherever feasible in the consideration of problems of mutual interest.

2. A preliminary meeting was held at the A.S.T.M. headquarters, Philadelphia, on January 7, 1920, with the following representatives present:

A.S.T.M. Sub-Committee VIII on Steel Castings.—

Bethlehem Steel Co., H. T. Morris, Represented by W. R. Shimer.
American Locomotive Co., E. J. Edwards.
American Steel Foundries, J. C. Davis, Represented by G. G. Floyd.
Birdsboro Steel Foundry and Machine Co., J. E. McCauley, Represented by J. V. R. Stehman.
Bureau of Construction and Repair, U. S. N., Represented by Capt. W. J. Baxter.
Egan-Rogers Steel and Iron Co., J. I. Rogers.
General Electric Co., J. M. Darke, Represented by W. E. Barnes.
National Malleable Castings Co., W. G. Kranz, Represented by H. W. Gilbert.
Penn Seaboard Steel Corporation, Craig Adair, Represented by T. Burd Zell.
Pennsylvania Railroad, Eastern Lines, F. M. Waring.
Standard Steel Works Co.,
    A. A. Stevenson.
    L. H. Fry.
Union Pacific System, N. F. Harriman.
U. S. Railroad Administration, J. R. Onderdonk.
Philadelphia and Reading Railway, J. B. Young.
Baldwin Locomotive Works,
    R. P. Johnson.
    H. V. Wille, Represented by J. A. Hance.

C. L. Warwick, Secretary-Treasurer, American Society for Testing Materials.

A.R.A. Committee on Specifications and Tests for Materials.—

F. M. Waring (*Chairman*).
J. R. Onderdonk.
I. S. Downing, Represented by I. S. Pearce.
F. Zeleny.
A. H. Fetters.
H. B. MacFarland.
H. G. Burnham.
H. E. Smith.
J. C. Ramage.
L. K. Sillcox, Represented by H. K. Fox.
C. B. Young, Represented by H. E. Smith.

A.R.A. Committee on Car Construction.—
W. F. Kiesel, Jr. (*Chairman*).

A.R.A. Committee on Couplers and Draft Gears.—
R. L. Kleine (*Chairman*).
L. E. Endsley.

V. R. Hawthorne, Section III—Mechanical, A.R.A. (*Secretary*).

United States Railroad Administration.—
H. E. Smith.

Manufacturers.—
Buckeye Steel Castings Co., Geo. T. Johnson.
Scullin Steel Co., H. E. Doerr.
Pratt and Letchworth Co., H. M. Lewis.
Union Steel Castings Co., J. Lloyd Uhler.
Baldwin Locomotive Works,
R. P. Johnson.
H. V. Wille, Represented by J. A. Hance.

New York Central Lines, G. E. Doke.

3. On motion, Mr. F. M. Waring was elected Temporary Chairman, and Mr. C. L. Warwick, Temporary Secretary.

4. Mr. C. L. Warwick presented a summary of the efforts leading up to the call for this meeting and had read into the minutes the text of the agreement between the A.S.T.M., the A.R.A. and the U.S.R.A. for the joint preparation of new standards.

5. Since the representatives present had not been definitely instructed to act by their respective executive boards, no permanent organization could be effected and after announcement of the tentative membership the meeting was thrown open to a general discussion of specification requirements.

As a result of this discussion, and after many modifications, the following proposed grades and physical properties were suggested:

SUBJECT TO CHEMICAL.	SUBJECT TO PHYSICAL AND CHEMICAL.[1]	
A	B	C
	Tensile Strength not specified.	Tensile Strength not specified.
	Elastic Limit, min., lb. per sq. in., 26 000	Elastic Limit, min., lb. per sq. in., 32 000
	Yield Point, min., lb. per sq. in., 29 000	Yield Point, min., lb. per sq. in., 36 000
	Elastic Limit × Elong. in 2 in., min., = 700 000	Elong. in 2 in., min., per cent, 22
		Reduction of area, min., $\frac{1\,400\,000}{\text{El. Limit}}$
		Elastic Limit × Elong. in 2 in., min. = 850 000
		Yield Point × Elong. in 2 in., min. = 952 000

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[1] For couplers, truck sides, bolsters and guide yokes.

	For Locomotive Frames.	
	A	B
Tensile Strength, lb. per sq. in.	75 000	65 000
Elastic Limit, lb. per sq. in.	0.4 Tens. str.	0.4 Tens. str.
Elongation in 2 in., per cent	$\frac{1\,600\,000}{\text{Tens. str.}}$	$\frac{1\,600\,000}{\text{Tens. str.}}$
Reduction of area, per cent	30	35
Yield Point, lb. per sq. in.	0.45 Tens. str.	0.45 Tens. str.

6. The meeting adjourned after fixing January 28, 1920, as the date for permanent organization.

7. The second meeting was held January 28, 1920, at the A.S.T.M. headquarters, Philadelphia, with Mr. A. A. Stevenson presiding and the following accredited representatives present, except as noted:

American Society for Testing Materials.—

- American Steel Foundries,
    - G. G. Floyd.
    - J. C. Davis.
- Standard Steel Works,
    - A. A. Stevenson.
    - L. H. Fry.
- Penn Seaboard Steel Casting Co.,
    - Craig Adair.
    - R. H. Norton.
    - T. Burd Zell.
- National Malleable Castings Co., H. W. Gilbert.
- Eagan-Rogers Steel and Iron Co., John I. Rogers.
- Birdsboro Steel Foundry and Machine Co., J. E. McCauley.
- Union Steel Castings Co., J. Lloyd Uhler.
- Pratt and Letchworth Co., H. M. Lewis.
- Union Pacific Railroad, N. F. Harriman.
- Philadelphia and Reading Railway, J. B. Young.
- Norfolk and Western Railroad, J. H. Gibboney.
- American Locomotive Co., E. J. Edwards.
- Baldwin Locomotive Works, R. P. Johnson.

C. L. Warwick, Secretary-Treasurer, A.S.T.M.

American Railroad Association.—

COMMITTEE ON SPECIFICATIONS AND TESTS.	COMMITTEE ON CAR CONSTRUCTION.	COMMITTEE ON COUPLERS.
J. R. Onderdonk.	J. A. Pilcher.	R. L. Kleine, Represented by F. M. Waring.
H. B. MacFarland.		Geo. T. Johnson.
I. S. Downing, Represented by G. E. Doke.		
F. M. Waring.		

Also,

- Canadian Pacific Railroad, Mr. Robert Job and W. A. Newman.
- New York Central Railroad, B. B. Milner, Represented by G. E. Doke.
- The Bettendorf Co., P. Bendixen.
- Scullin Steel Co., H. E. Doerr.

The following representatives were absent:

A. H. Fetters.
H. G. Burnham.
A. R. Ayers.
United States Railroad Administration, H. E. Smith.
Pressed Steel Car Co.
F. Zeleny.

8. The Joint Committee organized by electing Mr. F. M. Waring as chairman.

9. The meeting was then opened by an informal discussion of the existing steel casting specifications of the A.R.A. and A.S.T.M. and the advisability of using one or the other as a basis for joint specifications. Remarks made by Mr. W. F. Kiesel, Jr., Chairman, Car Construction Committee, A.R.A. at the previous meeting were fully discussed since his suggestions had been incorporated in the tables of physical properties proposed at that meeting.

Mr. Kiesel had said in part:

> "Locomotive frames should be of the highest grade steel. Car side frames, bolsters and couplers should be of a higher grade steel than ordinary castings. Two grades of steel should be sufficient. It is desirable to make the physical properties based on elastic limit because the elastic limit and elongation are the prime factors in specifications. We should have steel for side frames, bolsters, couplers and locomotive frames on which the product of the elastic limit by the elongation is not less than 850,000. For ordinary castings a product of 700,000 or 750,000 would be sufficient. I would like to see in this specification a minimum requirement for elastic limit and elongation."

Some consumers spoke with particular reference to the desires of railroad designers for a material that would have not only a higher elastic limit than was provided for in existing specifications but also greater ductility such that the product of the elastic limit by the elongation in 2 in. would be not less than certain specified constants.

It was brought out in the discussion that such a method of expressing physical requirements was quite new to the majority of the members and would require further consideration before definite action was taken.

10. On motion, a sub-committee was appointed to draft an outline of specifications with chemical and physical requirements for as many grades of steel as they might consider necessary. The following were appointed:

American Society for Testing Materials.—

American Steel Foundries, J. C. Davis (*Chairman*).
Union Steel Castings Co., J. Lloyd Uhler.
Pratt and Letchworth Co., H. M. Lewis.
American Locomotive Co., E. J. Edwards.

American Railroad Association.—

J. R. Onderdonk.
H. B. MacFarland.
J. A. Pilcher.

United States Railroad Administration.—

H. E. Smith.

The meeting adjourned to await the report of the sub-committee.

11. The sub-committee held its first meeting at the Wm. Penn Hotel, Pittsburgh, on February 25, 1920, and drafted specifications which were presented to a meeting of the Joint Committee held in Philadelphia, April 15, 1920, with the following present:

American Society for Testing Materials.—

Standard Steel Works Co.,
  A. A. Stevenson.
  L. H. Fry.
Baldwin Locomotive Works, H. V. Wille, Represented by J. A. Hance and R. P. Johnson.
Philadelphia and Reading Railway, J. B. Young
Union Pacific Railroad, N. F. Harriman.
Pratt and Letchworth Co., H. M. Lewis.
Commonwealth Steel Co.,
  H. M. Pflager.
  John M. Locke.
Union Steel Castings Co., J. Lloyd Uhler.
Egan-Rogers Iron and Steel Co., John I. Rogers.
Birdsboro Steel Foundry and Machine Co., J. E. McCauley.
Pressed Steel Car Co., J. F. Streib.
American Steel Foundries, J. C. Davis, Represented by Geo. G. Floyd.

American Railroad Association.—

H. B. MacFarland.
J. R. Onderdonk, Represented by W. E. F. Armstrong.
I. S. Downing, Represented by G. E. Doke.
Canadian Pacific Railroad, Robert Job.
W. F. Kiesel, Jr.
Geo. T. Johnson.

United States Railroad Administration.—

H. E. Smith.

12. The proposed specifications had the following chemical and physical requirements:

CHEMICAL PROPERTIES.

	SOFT.	MEDIUM.	HARD.
Manganese, per cent, not over..........	0.85	0.85	0.85
Phosphorus, per cent, not over..........	0.06	0.055	0.05
Sulfur, per cent, not over..............	0.06	0.06	0.06

PHYSICAL PROPERTIES.

	SOFT.	MEDIUM.	HARD.
Tensile strength, lb. per sq. in...	65 000	72 500	80 000
Elastic limit, lb. per sq. in......	0.4 tens. str.	0.4 tens. str.	0.4 tens. str.
Yield point, lb. per sq. in......	0.45 tens. str.	0.45 tens. str.	0.45 tens. str.
Elongation in 2 in., per cent..	$\frac{1\,600\,000}{\text{Tens. str.}}$	$\frac{1\,600\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$
"	not under 22 per cent	not under 19 per cent	not under 16 per cent
Reduction of area, per cent..	35	28	22

The remainder of the specification closely followed the wording of existing A.R.A. specifications.

13. An abstract of the sub-committee's report follows:

"Your committee was confronted with several problems, the chief of which was the adaptation of specifications to the varied requirements of the users of steel castings, and at the same time not impose upon the producers, conditions which were not consistent with modern practice as current in well-conducted foundries. That is to say, it is recognized by the responsible factors in the better-class foundries that the developments in railroad operating practice with respect to locomotive and rolling stock, have overtaken and exceeded certain features of some existing specifications and therefore there is automatically created a demand for a higher grade of material than, for instance, was expected when the last M.C.B. specifications were adopted. At the same time, through contact with the various able mechanical officials of the country, the manufacturers have been impressed with the very considerable differences of opinion which exist as to what character of steel is best suited for certain purposes. For instance, the three grades of steel coming within the scope of the subjoined proposed tentative specifications all have their advocates for use in locomotive frames.

"In this connection a considerable establishment under a normal demand and with prompt deliveries expected, is called upon to cast a great variety of shapes for a single heat, the requisitions being issued upon the basis of the customers' needs and naturally without regard to a properly normal scheduling of the work in the foundry in order that molds might be made and cast in specification groups. The result of this variation imposes a needless hardship upon the manufacturer and is therefore entitled to serious consideration, not only for the reasons given but it has a decided influence upon the ability of the manufacturer to render to the user the service he requires, be it a matter of prompt delivery or adaptation of quality, or both.

"These facts were recognized by those members of your sub-committee who represent railroad interests, since they have had very wide experience in such matters, and therefore the subject was approached by your entire committee without prejudice, and having in mind such a wide application of values as practically to insure the cooperation and resulting coordination as between the parties in interest.

ELASTIC LIMIT AND YIELD POINT.

"A careful consideration seems unmistakably to warrant the perpetuation of factors previously adopted, until such time as more definite information with respect to determining these values shall have been developed.

ELONGATION AND REDUCTION OF AREA.

"Your committee believes that the ductility factors are sufficiently liberal to meet all requirements as to safety.

SULFUR AND PHOSPHORUS.

"Sulfur is generally recognized as not materially affecting the properties of steel in the cold state unless present in amounts greatly in excess of any existing specifications. On the other hand, the user of steel castings is protected in the matter of this element for the reason that the manufacturer will restrict its presence all possible since, were he not to do so his foundry losses would be ruinous. Therefore, in view of these facts, and having in mind the extreme difficulty of obtaining any fuel at all (1920), much less a full requirement of high-grade fuel, an extension of the maximum limit of 0.06 per cent is freely recommended.

"The situation at the present time with respect to low phosphorus melting scrap is serious for the many foundries which employ the acid open-hearth process for producing steel.

"Since these are conditions which will not be under control for an indefinite period, your committee has adjusted the phosphorus specification upon a sliding scale based upon the minimum tensile strengths of the three grades of steel, having in mind the generally accepted fact that the influence of phosphorus is directly as the tensile strength within certain broad limits. It is expected, however, that at such time as suitable materials shall have become generally available this item will be modified."

14. The committee considered the chemical and physical requirements and after considerable discussion Mr. W. F. Kiesel, Jr., offered the following substitute for the proposed physical properties:

	GRADE A.	GRADE B.	GRADE C.
Elastic limit, lb. per sq. in......	26 000	32 000	40 000
Elongation in 2 in., per cent.....	$\frac{700\,000}{\text{E. L.}}$	$\frac{850\,000}{\text{E. L.}}$	$\frac{850\,000}{\text{E. L.}}$
Reduction of area, per cent.....	$\frac{975\,000}{\text{E. L.}}$	$\frac{1\,200\,000}{\text{E. L.}}$	$\frac{1\,200\,000}{\text{E. L.}}$

Mr. Kiesel stated in explanation of the proposed table of physical properties that from the designer's standpoint the elastic limit and elongation in 2 in. were the two properties of fundamental importance on which to base allowable stresses, and that the reduction of area might be considered as of importance in determining the quality of annealing. The designer was not concerned with the ultimate strength of the material and therefore it was unnecessary to specify this. Following Mr. Kiesel's explanations, the idea of expressing the physical properties in the form suggested was fully discussed and the limits given were commented upon for and against by both consumers and producers. It was the opinion that Grade A steel would correspond approximately to the present soft grade in the A.S.T.M. specifications, and Grade B steel to the present hard grade, and the Grade C steel was of a special nature not heretofore covered by specifications.

15. The Joint Committee then voted to appoint a sub-committee of four members to investigate the establishing of methods of tests, particularly with reference to the determinations of elastic limit and yield point. The sub-committee consisted of the following:

Mr. Frank Zeleny (*Chairman*).
American Steel Foundries, Mr. J. C. Davis.
Mr. Geo. T. Johnson, The Buckeye Steel Castings Co.
Mr. H. G. Burnham.

NOTE.—This sub-committee endeavored to develop a device for centralizing the pull on a tension test specimen with a special form of grip and testing apparatus but the results were not conclusive. A large number of special tests on elastic limit and yield point determinations were made by individual members of the sub-committee and some of these results will be made available in papers to be presented to the American Society for Testing Materials. This sub-committee never made a formal report to the Joint Committee and because of the difficulties of carrying on research work of this kind it was decided at the meeting of the Joint Committee held March 24, 1922, to discharge the sub-committee; therefore no further reference will be made to it.

16. As a result of the discussion the proposed specifications were referred back to the sub-committee with certain instructions of which the following is a summary:

(*a*) That the proposed specifications contain the physical properties expressed in a form based on the elastic limit with the elongation in 2 in. and reduction of area expressed in terms of the elastic limit, and that the sub-committee make definite recommendations as to the number of classes of steel to be covered and what the physical properties for these classes should be, giving consideration to the proposed physical properties given above.

(*b*) That Grades A and B given above may be considered as a substitute for the three grades proposed in the sub-committee's report of March 11, and that Grade C given above be considered as a special steel that may be ordered for certain constructions.

(*c*) That consideration be given to preparing specifications for unannealed castings and including in the specifications requirements for such castings as are to be accepted on surface inspection only, without tension tests.

(*d*) That consideration be given to the wording of Paragraph 9 (*b*) in the proposed specifications in order to clear up the meaning.

(*e*) That consideration be given to the omission of the manganese requirement in Paragraph 4 on chemical composition.

(*f*) That consideration be given to the elimination of entire Paragraph 2 on "Process." For the information of the sub-committee the vote on this motion was 18 affirmative, 2 against; total present, 20.

(*g*) That consideration be given to the omission of the entire Paragraph 1 (*b*) covering the purpose for which the castings are to be used. For the information of the sub-committee the vote on this motion was 6 for, 6 against, 8 not voting; total, 20.

17. The sub-committee on specifications held another meeting at Pittsburgh on May 27, 1920, made certain revisions which were circulated among its members and manufacturers for consideration and criticism.

18. Several changes in membership of the Joint Committee were made from time to time. The representation of the United States Railroad Administration lapsed with the passing of that organization. A list of the members as of March, 1922, is given below.

19. The sub-committee on specifications held a meeting in Pittsburgh on January 18, 1922, and considered criticisms of members and others interested who had been consulted regarding the draft prepared on May 27, 1920. A new draft was prepared and reported to the Joint Committee at a meeting held in Philadelphia, March 24, 1922, with the following members present except as noted:

American Society for Testing Materials.—

American Steel Foundries, J. C. Davis.
American Locomotive Co., E. J. Edwards.
Baldwin Locomotive Works, H. V. Wille, Represented by R. P. Johnson.

Birdsboro Steel Foundry and Machine Co.,
    J. E. McCauley.
    J. V. R. Stehman.
Bethlehem Steel Co., H. T. Morris.
Commonwealth Steel Co., H. M. Pflager, Represented by J. H. Locke.
Eagan-Rogers Steel and Iron Co., John I. Rogers.
National Malleable Castings Co., H. W. Gilbert.
Norfolk and Western Railroad, J. H. Gibboney.
Penn Seaboard Steel Casting Co., H. A. Baxter, Represented by M. R. Maclean.
Pratt and Letchworth Co., H. M. Lewis (Absent).
Philadelphia and Reading Railway, J. B. Young.
Pressed Steel Car Co., J. F. Streib (Absent).
Standard Steel Works Co.,
    A. A. Stevenson.
    L. H. Fry (Absent).
Union Steel Castings Co., J. Lloyd Uhler.
Union Pacific Railroad, W. M. Barr (Absent).
Westinghouse Electric and Manufacturing Co.,
    T. D. Lynch.
    John Y. Hessells.

A.R.A. Committee on Specifications and Tests for Materials.—
J. R. Onderdonk, Baltimore and Ohio Railroad.
A. H. Fetters, Union Pacific Railroad (Absent).
Frank Zeleny, Chicago, Burlington and Quincy Railroad (Absent).
H. G. Burnham, Northern Pacific Railway (Absent).
T. D. Sedwick, Chicago, Rock Island and Pacific Railroad, Represented by C. L. Buckingham.
G. E. Doke, New York Central Railroad.
F. M. Waring, Pennsylvania System (*Chairman*).

A.R.A. Committee on Car Construction.—
A. R. Ayers, New York Central and St. Louis Railroad, Represented by A. T. Streeper.
J. A. Pilcher, Norfolk and Western Railroad, Represented by J. H. Gibboney.

A.R.A. Committee on Couplers.—
R. L. Kleine, Pennsylvania System (Absent).
Geo. T. Johnson, The Buckeye Steel Castings Co.

W. H. Winterrowd, Canadian Pacific Railroad (Absent).

20. Mr. J. C. Davis, chairman of the sub-committee, expressed for his committee the feeling that they had covered in full all of the various opinions and criticisms submitted to them and had complied to the best of their ability with suggestions given them by the Joint Committee, although in some cases the conclusions were not in agreement with such suggestions. It was felt that the sub-committee could do nothing further towards securing an agreement and recommended that it be discharged. The sub-committee's report is given below practically in full:

"The Joint Committee on Steel Castings for Railroads held a meeting Thursday, April 15, 1920, and at this meeting issued instructions to the sub-committee to reconsider parts of certain sections of the specifications proposed by the sub-committee at a meeting held February 25, 1920. All of the various items have had careful consideration and as the result of further study of the situation it will be noted that the revised proposal embodies substantial changes.

"The two most important sections consist of Physical Properties as applied to two grades or classes of steel instead of three and Method of Determining Physical Properties; and Chemical Composition. Considering these in the order named, it is submitted:

PHYSICAL PROPERTIES.

"Since the meeting of your sub-committee held February 25, 1920, a very large number of tension tests has been made in an effort to develop commercial methods which would make it possible to definitely determine the elastic limit of specimens taken from steel castings. The result of these efforts has been rather to cloud the issue and substantiate the opinion held firmly by many that the term 'elastic limit' has been, and is being rather loosely used, and that its determination by existing methods is subject to serious fluctuations not properly indicative of the real quality of the metal under test.

"The sensitiveness of the instruments used constitutes a refinement which may be misleading, especially when used for purposes of commercial testing. That is to say, the determination of elastic limit through the use of an extensometer is greatly influenced by the delicacy of the particular instrument used.

"A further phase of this situation which is worthy of serious consideration is that which involves the use of a measuring instrument of the refinements of an extensometer, in conjunction with a mechanism for applying and indicating the load, the inherent inertia of which varies as the capacity of the machine, also as its physical condition.

"It should therefore be apparent that until these problems of tension testing shall have been clarified it is wise, on the part of both manufacturer and consumer, to adopt a method of testing which may be accepted as conclusive in the light of present knowledge concerning the subject.

"Yield point as shown by the drop of the beam indicates a definitely permanent set of the metal. Furthermore, the yield point as evidenced by hundreds of carefully made tests, bears a sufficiently fixed relation to the ultimate strength of a given class of steel to make consistent its use as a basis for the design of the various forms comprised of cast steel.

"The minimum allowable yield points for Grades A and B are in conformity with the figures given in Proposed Tentative Specifications for Carbon-Steel Castings issued by the American Railway Association under date of May 28, 1921. The natural assumption is that these figures are acceptable to the consumers since they were adopted by them, and likewise to the manufacturers, as hundreds of tests, of which these figures are a summation, demonstrate that the requirements are consistent with every-day modern practice.

"The substitution of two grades of steel for three grades is based upon the fact that practically all of the cast steel produced for railroad use falls clearly within the entire range of the requirements indicated under the two grades in question. It therefore seems superfluous to include in the specifications a third grade, since it so rarely is called for either above or below the proposed two grades, that it should be the subject of a separate specification and undertaking.

CHEMICAL COMPOSITION.

"During the period when the first proposal of your sub-committee was submitted it was still extremely difficult to obtain fuel and melting materials which would make it possible to produce steel castings, particularly in an acid furnace, which would contain a maximum of 0.05 per cent in phosphorus and sulfur. Since that time there has developed a substantial change in the situation with the result that it now is possible to obtain materials which enable the foundries to produce steel containing a maximum of 0.05 per cent in phosphorus and sulfur, and hence the proposal of your sub-committee is in conformity therewith.

"While the voting of the members of your sub-committee was finally unanimous with respect to the chemical elements proposed, your chairman feels it safe to suggest that there still might have been some mental reservations on the part of some members of the committee concerning the items of manganese and sulfur. It may or may not be the case that the influence of manganese within reasonable limits is a matter of tradition in the minds of some individuals. To the steel foundryman an excess of sulfur is a serious thing and he well knows that his best interests from the standpoint of cost of production lie in the direction of keeping this element at the lowest possible point, and at any rate not above the requirement of the proposed specification. On the other hand, no amount of sulfur which is likely to occur in steel castings as made nowadays should concern the purchaser as an influence upon the physical properties of the castings which may be submitted for his use."

21. The report of the sub-committee was approved and the proposed specifications discussed section by section. Several changes were made to clarify the meaning of certain sections but no changes were made in substance of the requirements, chemical and physical, as recommended by the sub-committee. The specifications were then approved to go to letter ballot of the Joint Committee after which they are to be submitted by the representatives to their respective parent bodies, the A.S.T.M. representatives to report to Committee A-1 on Steel, and the A.R.A. representatives to Mr. V. R. Hawthorne, Secretary, Mechanical Division.

The sub-committee on specifications was discharged with the thanks and appreciation of the Joint Committee for the labors it had performed and the difficulties it had overcome in attempting to harmonize conflicting opinions of consumers and manufacturers.

It is understood that the parent organizations will receive and act upon the reports of their representatives. Should their action be unfavorable, or certain changes be suggested, then the representatives will bring the matter before the Joint Committee for action. Until such time the Joint Committee has adjourned to await the call of the chairman.

Respectfully submitted for the Joint Committee,

F. M. WARING,
Chairman.

EFFECT OF SULFUR ON RIVET STEEL.

PRELIMINARY REPORT OF THE JOINT COMMITTEE ON INVESTIGATION OF PHOSPHORUS AND SULFUR IN STEEL.[1]

ORGANIZATION.

The investigation on effect of sulfur on rivet steel is part of a comprehensive study of the effect of phosphorus and sulfur in steel, begun in 1920 under the joint initiative of the American Society for Testing Materials, the U. S. Bureau of Standards, and the then existing U. S. Railroad Administration. A joint committee was formed, upon which the following organizations are now represented:

ORGANIZATIONS	REPRESENTED BY
U. S. Bureau of Standards	George K. Burgess, *Chairman* H. L. Whittemore
American Society for Testing Materials	Robert W. Hunt Co. (J. F. Davis) T. D. Lynch C. L. Warwick, *Secretary* (*Ex-Officio*)
American Railway Association, Mechanical Division	F. M. Waring H. E. Smith
U. S. War Department	F. C. Langenberg
U. S. Navy Department	D. J. McAdam, Jr.
Society of Automotive Engineers	F. P. Gilligan
Society of Naval Architects and Marine Engineers	F. W. Wood
National Research Council, Engineering Division	John H. Hall
Association of American Steel Manufacturers	E. F. Kenney J. J. Shuman
Steel Founders Society of America	J. E. McCauley
American Foundrymen's Association	R. A. Bull

The entire investigation includes a study of the effect of sulfur and phosphorus upon steel in which the sulfur is residual (Series A), and steel in which sulfur may be added during the later stages of manufacture before reaching the mold, in the form of additions to be determined (Series B). The material in Series A covers six groups, as follows:

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[1] Published by permission of the U. S. Bureau of Standards.

GROUP NO.	MATERIAL.	APPROXIMATE CARBON RANGE, PER CENT.
1	Rivet steel, tubes, etc	0.06 – 0.12
2	Plates and structural shapes	0.16 – 0.22
3	Forgings	0.45 – 0.55
4	Wheel, tire and rail steels	0.65 – 0.75
5	Spring steels	0.95 – 1.05
6	Castings	To be determined

In all groups, when determining the effect of sulfur, the sulfur content ranges in general from 0.03 to 0.08 per cent, with phosphorus and other elements normal and as nearly constant as possible. When determining the effect of phosphorus, the phosphorus content will range in general from 0.02 to 0.08 per cent, with sulfur and other elements normal and as nearly constant as possible.[1]

The investigation is being conducted on the "unanimous consent" basis; that is, every step of the program must be acceptable to all parties.

The manufacture of all material for the investigation is under the direct supervision of a Committee on Manufacture, of which George K. Burgess is chairman. All tests are made under the direction of a Committee on Tests. F. C. Langenberg is chairman of this committee and has supervised all tests at Watertown Arsenal; the tests at the U. S. Naval Engineering Experiment Station have been directed by D. J. McAdam, Jr. Other committees are those on Statistics, H. L. Whittemore, chairman; on Service Tests, F. P. Gilligan, chairman; on Finance, C. L. Warwick, chairman; and on Publicity, George K. Burgess, chairman.

The Committee also wishes to acknowledge its indebtedness to Mr. C. F. W. Rys, Metallurgical Engineer of the Carnegie Steel Co., who collaborated in the securing of the rivet steel for the investigation; Mr. A. L. Meyer, Chemical and Metallurgical Engineer of the Lukens Steel Co., who has assisted Mr. E. F. Kenney in the committee work; Mr. N. Richardson, who has assisted Mr. Langenberg in the work of the Committee on Tests; and Mr. C. H. Strand, who has assisted the Chairman.

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[1] A complete account of the program of tests, with notes on material to be secured and general methods to be followed in conducting the investigation, was published in the Report of Committee A-1 on Steel at the 1920 meeting of the American Society for Testing Materials. See *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, pp. 139–142 (1920).

INTRODUCTION.

The Joint Committee on Investigation of Phosphorus and Sulfur in Steel has completed that portion of the investigation relating to the determination of the effect of sulfur on rivet steel. Fourteen heats of basic open-hearth steel, varying in sulfur content from approximately 0.03 to 0.08 per cent, with one heat as high as approximately 0.18 per cent, were made especially for this investigation by the Carnegie Steel Co., under the immediate direction of the Committee. Carbon, manganese and phosphorus contents were normal for rivet steel, and were kept as nearly constant as possible. The sulfur was "residual sulfur," that is, sulfur present in the steel through its presence in fuel or in pig or scrap and not through additions made in the ladle or mold. Sufficient material for test was furnished from each heat in the form of $\frac{63}{64}$-in. bars, $\frac{63}{64}$-in. button-head and cone-head rivets in three lengths, and slabs $5\frac{1}{4}$ by 1 in.

The material was tested in the natural condition "as received," in annealed condition and in quenched condition. The bars were tested in tension, impact, hardness, bend, torsion and shear. The rivets were tested as follows: Shanks bent cold in natural condition; shanks bent cold in quenched condition; heads flattened hot; shanks flattened hot; shanks upset cold; and shanks upset hot. Riveted joints with rivets in single and double shear were also tested. In order to study fully the effect of sulfur on the properties of this steel, tests were made upon specimens having their longitudinal axes perpendicular to the direction of rolling. Suitable specimens were secured from $5\frac{1}{4}$ by 1-in. slabs rolled from billets from each of the fourteen heats and were tested in tension, impact, hardness, bend and shear.

One set of material was tested at the laboratory of Watertown Arsenal, Watertown, Mass., and a duplicate set was tested at the laboratory of the U. S. Naval Engineering Experiment Station, Annapolis, Md. In general, identical tests were made at the two laboratories; methods of testing were carefully prescribed in advance and followed in each laboratory as exactly as possible. A triplicate set of material is held in reserve at the U. S. Bureau of Standards.

In this investigation there were 19 kinds of tests made, including the chemical analysis as one test. The total number of physical tests was approximately 5230, and over 1000 chemical determinations were made.

The complete investigation, with full descriptive matter, will ultimately be published as a technologic paper of the U. S. Bureau of Standards. The Joint Committee, however, desires to make the data available as soon as possible for the general information of all interested and to bring out comment and discussion. The present Preliminary Report is therefore published, with the approval of the Bureau of Standards, as a "preprint" of the American Society for Testing Materials, for presentation and discussion at its Annual Meeting in June, 1922. This report is limited to the presentation of the essential test data in graphical form, with only sufficient explanatory text to make the report clear and self-contained. The graphical form of presenting the data has obvious advantages over the tabular form for a preliminary report, enabling the reader more readily to obtain a general oversight of the results. The complete publication will contain tables, photomicrographs, illustrations of specimens and much descriptive matter that are omitted from the present report.

Although the Joint Committee has fully reviewed all the test data herein presented, it has decided, for the present, to defer the drawing and publishing of formal conclusions.

DESCRIPTION OF MATERIAL.

The steel for this investigation was manufactured by the Carnegie Steel Co. at their Duquesne Works. In January, 1920, the Committee on Manufacture visited these works and witnessed all stages of the process of manufacture of seven heats of basic open-hearth rivet steel and their rolling into rivet rounds. (Heats *F*, *G*, *H*, *J*, *K*, *P* and *M*, Table I.) Seventy-five-ton heats were used, material not required for the investigation being routed elsewhere. In the manufacture of this material neither the ingots nor billets were allowed to go cold. The Committee also accepted the offer of the company to furnish five ingots of basic open-hearth rivet steel, containing sulfur within the required range, that had been made a few weeks previously and set aside for possible use. The Committee witnessed the entire process of rolling these five ingots into rods. (Heats *A*, *B*, *C*, *D* and *E*, Table I.) Heats *S* and *R* were made and rolled into rods subsequent to the visit of the Committee. Complete data on the manufacture of all heats were obtained by the Committee, including details of the charge in the furnace, additions in the furnace and ladle, and temperatures of blooming and of rolling.

In Table I are given the average contents of sulfur, carbon, manganese, phosphorus and silicon, each value (except those for silicon) being the average of 14 analyses made as hereinafter described. The values for silicon are the average of two analyses. The ingots that were cold before rolling are identified.

Heat *M* showed the unusually high sulfur content on ladle analysis of 0.175 per cent. The Committee witnessed the tapping of this heat and it is certain that no sulfur additions were made either in the ladle or the molds; that is, the sulfur in this heat is "residual." The manufacturer stated that in making this heat a considerable quantity of boiler tubes was charged into the furnace, the inner surface of the tubes being coated with high-sulfur boiler scale, which in all probability accounted for the high sulfur content of the finished product.

Each ingot was 18 by 21 by 72 in. (approximately 6400 lb.). After a top discard of 40 per cent, each ingot was rolled into six billets 4 by 4 by 48 in. (approximately 220 lb.). The billets were numbered from one to six in sequence from the top of the ingot and each was stamped with the heat and billet number. Billets 1, 2, 3 and 4 from each ingot were rolled into $\frac{63}{64}$-in. rounds, each billet yielding eight bars 9 ft. 8 in. in length. Billets 5 and 6 from each ingot were later rolled into slabs.

All of the ingots and billets rolled satisfactorily, including the ingot from heat *M*, with the exception of the ingot from heat *P*, which cracked slightly in blooming.

The bars were segregated into eight separate and similar groups, each group containing one bar from each of the four billets rolled into bars from each ingot, a total of 56 bars. Each bar was marked with the heat letter and with the position in the ingot of the billet, that is, 1, 2, 3 and 4. It was not thought necessary to locate the position of the bar in the billet inasmuch as one billet represents only a small fraction of the original ingot weight. One group was sent to Watertown Arsenal, Watertown, Mass., a second to the U. S. Naval Engineering Experiment Station, Annapolis, Md., and a third to the Bureau of Standards, Washington, D. C. One group was retained by the manufacturer, and the remaining four groups were manufactured into rivets.

The rivets were made with two types of head, cone and button, the cone-head rivets being manufactured at the Altoona Shops of the Pennsylvania System, and the button-head rivets at the works of the Champion Rivet Co., Cleveland. Rivets were made in the lengths of $2\frac{3}{4}$, $3\frac{1}{2}$ and 6 in. Thirty-six rivets of each length and of each type of head were made from each heat, a total of 2808 rivets. (No rivets were made from heat *S*.) The rivets were headed at the two shops at average temperatures of 2090 and 1965° F., respectively. After heading, the rivets were stamped with the heat and billet number and one-third shipped to each of the three laboratories above mentioned. The manufacture of the rivets at both plants was witnessed by representatives of the Committee on Manufacture.

From billets 5 and 6 of each heat there were rolled late in 1920 flats 5¼ in. wide by 1 in. thick, 4 ft. 6 in. long, two from each heat. One flat from each heat was sent to Watertown Arsenal and the other to the U. S. Naval Engineering Experiment Station. These flats were rolled only in the lengthwise direction, and were used to secure specimens whose longitudinal axes were perpendicular to the direction of rolling, as described later.

DESCRIPTION OF TEST SPECIMENS AND METHODS.

One set of material was tested at the laboratory of Watertown Arsenal and a duplicate set was tested at the U. S. Naval Engineering Experiment Station. The test procedures outlined at the beginning of the investigation were followed as carefully and closely as possible by the two laboratories, so that the Committee has obtained directly comparable test data from two separate laboratories on material identical for all practical purposes. A brief description of the tests and methods follows.

TESTS OF RIVET BARS.

Rivet bars were tested in tension, impact (Charpy, Izod and impact shear), hardness (Brinell and scleroscope), bend, torsion and shear. The Izod impact tests were made only at Watertown Arsenal, and the impact shear tests only at the Naval Experiment Station. All other tests were made at both laboratories.

Of the 56 bars (four bars each from 14 heats) first sent to each laboratory, half (two bars from each heat) were tested in the natural condition "as received," and half in annealed condition. Later, one bar from each heat was sent to each laboratory from the reserve supply at the Bureau of Standards, and these were tested in the quenched condition.

Chemical Analyses.—At Watertown Arsenal, separate chemical analyses were made on drillings taken from a broken tension test specimen from each bar in natural and annealed condition, that is, four analyses per heat. At the Naval Experiment Station, separate analyses were made on drillings taken from samples cut from each end of each bar as delivered, that is, eight analyses per heat. No chemical analyses were made on the bars tested in the quenched condition. Sulfur, carbon, manganese and phosphorus were determined in each analysis, using the methods specified by the American Society for Testing Materials. The silicon contents reported are the average of two analyses from each heat, made at the Naval Experiment Station. Determinations to detect the presence of nickel and chromium were also made.

Heat Treatment.—The bars were first cut up into the required number of specimens. In the case of material to be heat-treated, the various pieces of bar thus obtained were annealed or quenched. In annealing, the pieces were heated to 925–950° C. (1687–1742° F.), held for one-half hour and cooled in the furnace. In quenching, the pieces were heated to 925–950° C. (1687–1742° F.); in the case of the Watertown Arsenal tests, they were held for one hour and in the case of the Naval Experiment Station tests for one-half hour before quenching in water at 21–23° C. (70–73° F.). All machine work on specimens requiring machining was done after heat treatment. That is, all heat treatment was done on full-size sections of the bars as rolled.

Number of Tests.—At Watertown Arsenal, there were made for each heat six tension tests, eight Charpy and eight Izod impact tests, two Brinell and two scleroscope hardness tests, six bend tests, six torsion tests and six shear tests for material in natural condition, a like number of tests for material in annealed condition, and one-half that number of tests for material in quenched condition. (Izod and shear tests for heat *S* in natural and annealed conditions were not reported by this laboratory.) At the Naval Experiment Station, there were made for each heat six tension tests, eight Charpy and eight impact shear tests, two Brinell and two scleroscope hardness tests, four bend tests, six torsion tests and two shear tests for material in natural condition and for material in annealed condition. For material in quenched condition, three tension tests, four Charpy and four impact shear tests, two Brinell and two scleroscope hardness tests, four bend tests, two torsion tests and two shear tests were made for each heat.

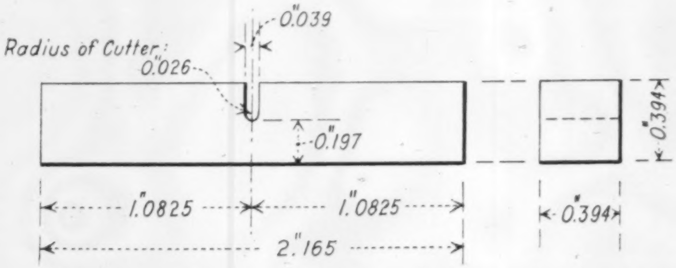

FIG. 1.—Test Specimen for Charpy Impact Test.[1]

In addition, Frémont impact tests were made at Watertown Arsenal on a total of 20 specimens from each heat for the three conditions, which are not given in this preliminary report. Including these tests, there were 3180 tests made on the rivet bars.

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[1] Specimen illustrated is that used at Watertown Arsenal. Specimen used at Naval Experiment Station differed only in that the radius at the bottom of the notch was 0.0197 in.

Specimens.—Tension test specimens were the standard A.S.T.M. specimens, 0.505 in. in diameter and 2-in. gage length, with threaded ends. The Charpy and Izod impact test specimens (notched) are illustrated in Figs. 1 and 2. The impact shear specimens (unnotched) were $\frac{3}{8}$ by $\frac{1}{4}$ by 3 in. The bend test specimens at Watertown Arsenal were full size, with the scale just turned off. At the Naval Experiment Station the bend test specimens were machined from the bars to rectangular form (approximately 1 by $\frac{1}{2}$ in. in cross-section) with corners rounded to a radius of $\frac{1}{16}$ in. The torsion test specimens ($9\frac{1}{4}$ in. long) were turned to a diameter of $\frac{3}{4}$ in. for a length of $5\frac{1}{4}$ in. with fillets at the shoulders of $\frac{3}{8}$-in. radius. The shear tests were made upon full-size specimens. All machine work was done at the respective laboratories.

Methods.—In general, the standard methods of the American Society for Testing Materials were followed where applicable. Tension tests at Watertown Arsenal were made on a 100,000-lb. Riehle testing machine. The specimens were pulled at a speed of 0.03 in. per minute up to the proportional limit and 1 in. per minute above the proportional limit. A Berry strain gage was used. At the Naval Experiment Station tension tests were made on a 50,000-lb. Olsen testing machine, with pulling speeds of 0.04 and 0.24 in. per minute below and above the proportional limit, respectively. A Riehle extensometer was used.

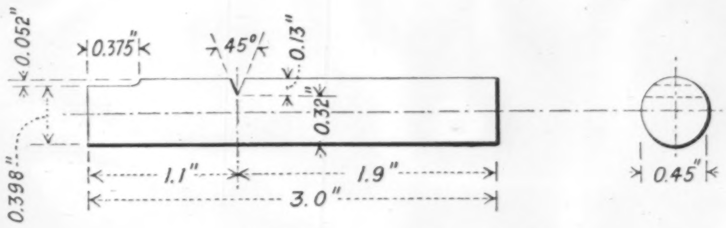

FIG. 2.—Test Specimen for Izod Impact Test.

In the impact tests, a 30-kg.-meter Charpy pendulum machine was used at each laboratory. The Izod impact tests were made at the Watertown Arsenal on a 125-ft-lb. Izod pendulum hammer machine. The impact shear tests were made at the Naval Experiment Station according to a method developed at the Station and published in a paper by D. J. McAdam, Jr., entitled "Endurance and Impact Tests of Metals."[1] The test consists of shearing an unnotched specimen by means of a swinging pendulum, the residual energy in the pendulum, as in the case of the Charpy and Izod notched impact tests, being measured by the height to which it swings after breaking the specimen.

Brinell hardness was determined at each laboratory upon a 3000-kg. Brinell machine. The Shore scleroscope was used in determining the scleroscope hardness; at the Naval Experiment Station a magnifying hammer was used and from the results were calculated the corresponding values for the universal hammer.

Bend tests were made by first bending the specimen to an angle of 60 deg., using a die block with faces at 60 deg. and nose rounded to a radius of $\frac{1}{4}$ in., and then to 180 deg. flat on itself between the heads of a tension testing machine. The 1 by $\frac{1}{2}$-in. specimen used at the Naval Experiment Station was bent with the 1-in. face against the die block.

Torsion tests at each laboratory were made on a 60,000-in-lb. Olsen testing machine. Up to the proportional limit, the angular speed used at Watertown Arsenal was 1.5 deg. per minute and at the Naval Experiment Station 1.26 deg. per minute; above the proportional limit, the angular speeds at the two laboratories were 180 and 160 deg. per minute, respectively.

The shear tests at both laboratories were made in a suitable double shear fixture, the load being applied with the tension testing machine.

TESTS OF RIVETS.

Rivets were tested as follows: Shanks bent cold in natural condition; shanks bent cold in quenched condition; heads flattened hot; shanks flattened hot; shanks upset cold; and shanks upset hot. Riveted joints with rivets in single and double shear were also tested. The hot flattening and hot upsetting tests on shanks were made only at Watertown Arsenal; all other tests were made at both laboratories.

Each laboratory received twelve rivets of each length ($2\frac{3}{4}$, $3\frac{1}{2}$ and 6 in.) and of each type of head, cone and button; a total of 72 rivets from each heat, excepting heat *S*, from which no rivets were manufactured.

No chemical analyses were made of any of the rivets, so that all tests are referred to the average chemical determinations made on the rivet bars and slabs for the respective heats.

The total number of tests of rivets was 962.

Bend Tests.—Bend tests on the shanks of 6-in. rivets (after removal of heads), in natural condition "as received" and in quenched condition, were made by bending cold through 180 deg. flat. At the Watertown Arsenal the bending was accomplished by means of a steam hammer; at the Naval Experiment Station it was done in a testing machine. At Watertown Arsenal, six rivets from each heat were tested in each condition. In quenching, the shanks were heated to 650° C. (1200° F.), held ten minutes and quenched in water at 21–27° C. (70–80° F.). At the Naval Experiment Station two rivets from each heat were tested in each condition. In quenching, the shanks were heated to 940° C. (1725° F.), held for one-half hour and quenched in water at 27° C. (81° F.). One half of the rivets tested at this laboratory had the surface scale removed by "rough-turning" in a lathe before bending.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part II, p. 299 (1916).

Flattening Tests.—Hot flattening tests were made on the heads and shanks of rivets. The heads were flattened while hot under a steam hammer to a diameter at least 2½ times the diameter of the shank. The temperatures of testing at Watertown Arsenal and the Naval Experiment Station were respectively 870° C. (1600° F.) and 982–1024° C. (1800–1875° F.). Three cone-head and three button-head rivets from each heat were tested at the former laboratory, and two rivets of each type from each heat at the latter.

Hot flattening tests on shanks were made by heating the shanks to 870° C. (1600° F.) and flattening at that temperature under a steam hammer to a thickness of approximately $\frac{1}{8}$ in., tapering to a thickness at the edge of $\frac{1}{32}$ to $\frac{1}{16}$ in. Three cone-head and three button-head rivets from each heat were tested.

Upsetting Tests.—Cold and hot upsetting tests were made on the shanks. The rivets were placed in a die with the head down and the end of the shank struck with a steam hammer. At Watertown Arsenal the length of the shank was reduced to one-third and at the Naval Experiment Station to two-thirds of the original length. The hot upsetting tests were made at a temperature of 982° C. (1800° F.). At Watertown Arsenal three rivets of each type from each heat were upset cold and a like number upset hot. At the Naval Experiment Station two rivets of each type from each heat were upset cold.

Tests of Riveted Joints.—In these tests chrome-nickel-steel plates $\frac{5}{8}$ in. thick were riveted together under standard conditions. At Watertown Arsenal two cone-head and two button-head rivets from each heat were tested in single shear and the same number in double shear. At the Naval Experiment Station six rivets of each type from each heat were tested in single shear and three in double shear. The plates were placed under tension in a tension testing machine.

TESTS OF "TRANSVERSE" MATERIAL FROM SLABS.

From the slabs (5¼ by 1 in.) rolled from each heat, specimens were secured whose longitudinal axes were perpendicular to the direction of rolling the slabs. These specimens were tested in tension, impact (Charpy and impact shear), hardness (Brinell and scleroscope), bend, and shear. The impact shear tests and the static shear tests were made only at the Naval Experiment Station, and the hardness tests were made only at Watertown Arsenal. The other tests were made at both laboratories.

TABLE I.—AVERAGE CHEMICAL COMPOSITIONS, WITH MEAN DIVERGENCES.

Each value (except those for silicon) is the average for separate analyses on 14 samples from each heat. The values for silicon are the average of separate analyses on two samples from each heat.
The heats are arranged in the order of increasing sulfur contents.

Heat Letter.	Ingot Hot or Cold	Sulfur, per cent.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent	Silicon, per cent.
A	Cold	0.0282 ± 0.0015	0.136 ± 0.0037	0.426 ± 0.021	0.0062 ± 0.0005	0.002
F	Hot	0.0317 ± 0.0016	0.149 ± 0.0043	0.642 ± 0.0075	0.0082 ± 0.0017	0.004
H	Hot	0.0355 ± 0.0015	0.110 ± 0.0025	0.362 ± 0.0037	0.0055 ± 0.0015	0.008
G	Hot	0.0367 ± 0.0020	0.137 ± 0.0037	0.466 ± 0.0037	0.0085 ± 0.0015	0.057
B	Cold	0.0377 ± 0.0009	0.112 ± 0.0080	0.392 ± 0.012	0.0082 ± 0.0009	0.005
C	Cold	0.0444 ± 0.0026	0.107 ± 0.0075	0.455 ± 0.005	0.0082 ± 0.0012	0.009
J	Hot	0.0492 ± 0.0016	0.107 ± 0.0037	0.355 ± 0.0062	0.0062 ± 0.0027	0.010
K	Hot	0.0580 ± 0.0030	0.115 ± 0.0050	0.411 ± 0.0087	0.0105 ± 0.0025	0.002
E	Cold	0.0606 ± 0.0033	0.104 ± 0.0037	0.457 ± 0.006	0.0105 ± 0.0010	0.005
D	Cold	0.0608 ± 0.0012	0.094 ± 0.0040	0.385 ± 0.015	0.0127 ± 0.0020	0.002
P	Hot	0.0633 ± 0.0018	0.116 ± 0.0037	0.432 ± 0.005	0.0240 ± 0.0030	0.004
S	Hot	0.0695 ± 0.0028	0.104 ± 0.0043	0.420 ± 0.020	0.0117 ± 0.0003	0.003
R	Hot	0.0834 ± 0.0033	0.106 ± 0.0037	0.472 ± 0.0025	0.0112 ± 0.0030	0.007
M	Hot	0.1793 ± 0.0027	0.106 ± 0.0037	0.512 ± 0.0075	0.0060 ± 0.0030	0.002

One slab from each of the 14 heats was tested at Watertown Arsenal and one at the Naval Experiment Station. At both laboratories material was tested in natural condition "as received" and in annealed condition. At the Naval Experiment Station, tests were also made on material in quenched condition.

Chemical Analyses.—Chemical analyses were made at Watertown Arsenal only, on drillings taken from two broken tension test specimens from each heat, one tested in the natural condition and one in the annealed condition.

Heat Treatment.—The procedure in annealing and quenching the specimens was exactly as described previously for the heat treatment of specimens from the rivet bars.

Number of Tests.—At Watertown Arsenal, there were made for each heat three tension tests, four Charpy impact tests, one Brinell and one scleroscope hardness test and three bend tests for material in natural condition, and a like number of tests for material in annealed condition. At the Naval Experiment Station, there were made for each heat two tension tests, four Charpy impact tests (two with impact in direction of long dimension of slab and two with impact at right angles to that dimension), eight impact shear tests (four with impact in direction of long dimension of slab and four with impact at right angles to that dimension), two bend tests and two shear tests for material in natural condition, and a like number of tests for material in annealed condition and in quenched condition. The total number of tests was 1092.

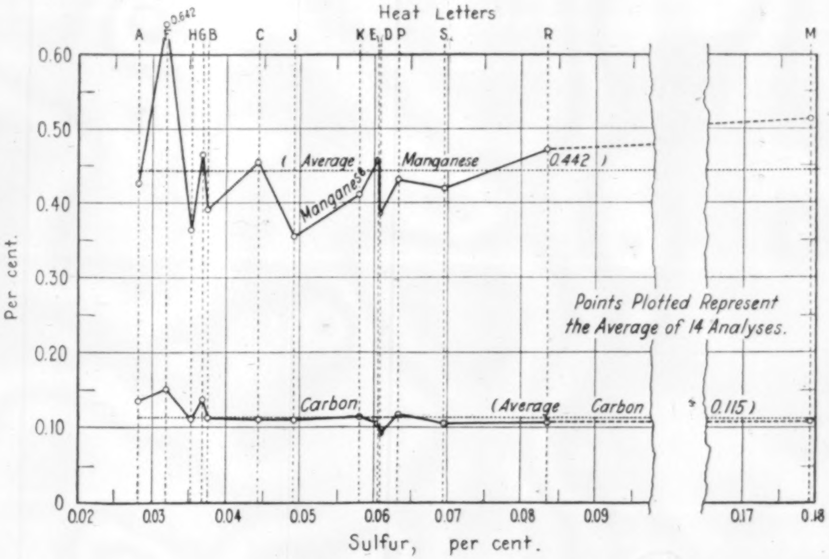

FIG. 3.—Average Carbon and Manganese Contents Plotted Against the Average Sulfur Content of Each Heat. (See Table I.)

Specimens.—The tension, impact and shear test specimens were of the same form and dimensions as previously described for tests on rivet bars. In both laboratories the bend test specimens were rectangular bars 1 by $\frac{1}{2}$ in. in cross-section, with corners rounded to a radius of $\frac{1}{16}$ in.

Methods.—The methods of testing used were as previously described for the tests on rivet bars. At the Naval Experiment Station the Charpy and impact shear tests were made with the direction of impact both in the direction of the long dimension of the slab and at right angles to the long dimension of the slab. In making the bend tests, the specimens were bent in a direction perpendicular to that of the long dimension of the slab, the bending in all cases being done with the 1-in. face of the specimen against the die block.

PRESENTATION OF TEST DATA.

As previously explained, separate chemical analyses were made on **14** samples of material from each heat, sulfur, carbon, manganese and phosphorus being determined in each analysis. Silicon was also determined on two samples from each heat. In order to obtain some uniform basis for plotting the physical properties, the Committee averaged for each heat the 14 reported determinations of sulfur, carbon, manganese and phosphorus. These average values, with the mean divergences, are given in Table I. The average sulfur content for each heat as thus determined is used for that heat throughout in plotting the figures. In Table I, the heats are arranged in the order of increasing average sulfur content.

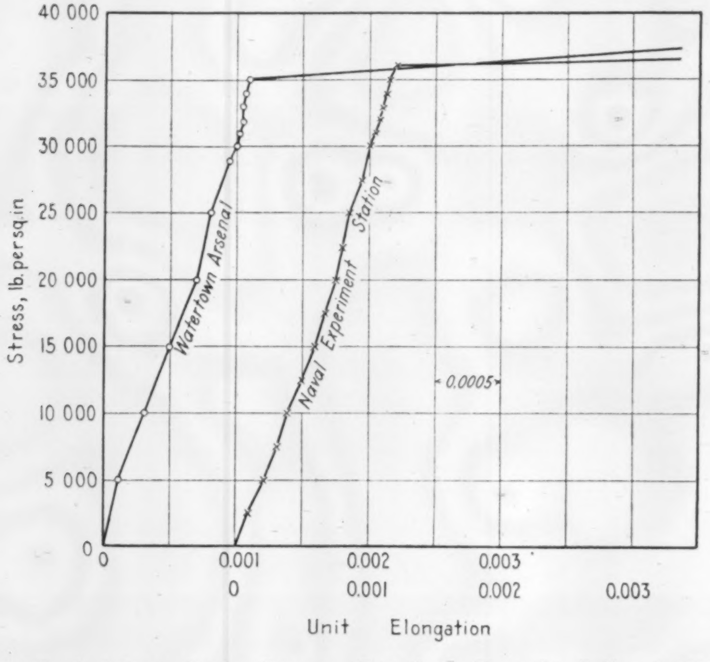

FIG. 4.—Typical Stress-Strain Curves. Bars from Heat *C*; Sulfur 0.0444 per cent. Natural Condition.

The average percentages of carbon and manganese have been plotted against the sulfur contents in Fig. 3. The phosphorus and silicon contents are low and quite uniform, and are not plotted on the figure. It was desired that the carbon in these steels should range from 0.06 to 0.12 per cent. It will be seen that only in the case of three heats (*A*, *F* and *G*) is the carbon content above 0.12 per cent. With these exceptions, the carbon content is quite uniformly in the neighborhood of 0.11 per cent. (The average of the carbon contents of all heats is 0.115 per cent.) There is a greater variation in the manganese content. The aim was to secure steels with manganese from 0.35 to 0.40 per cent. While none of the steels fell below 0.35 per cent of manganese, some ran much higher than was intended, heat *F*, for example, having the unusually high content for rivet steel of 0.642 per cent. (The average of the manganese contents of all heats is 0.442 per cent.) The influence of the higher manganese contents of heats *F* and *G*, combined with the higher carbon contents of the same heats, is clearly indicated in the study of the physical properties.

For the purpose of this preliminary report the Committee decided to present all of the data on physical tests in graphical rather than tabulated form, since the use of curves permits of far readier study of the significance of the tests. In the figures that follow, the percentages of sulfur are plotted as abscissas and the various properties determined are plotted as ordinates. Light vertical dotted lines are drawn at the average sulfur contents for each heat (Table I) and are marked with the corresponding heat letters. The same vertical scales are used in the different figures wherever possible, and the endeavor has been made in plotting properties expressed in different units to use proportionate scales. Thus, stresses in tension are reported between limits of 0 to 70,000 lb. per sq. in. and impact values between limits of 0 to 70 ft-lb. Hence, scales were adopted in plotting these values such that one space interval represents 10,000 lb. per sq. in. and 10 ft–lb., respectively. In this way comparative study of the curves is facilitated. The results obtained at the two laboratories are plotted separately. Straight lines have been drawn connecting the average of the values obtained at the two laboratories for successive heats, these averages being determined with regard to the number of tests of which each plotted value is the average.

Separate curves have been drawn for tests on material in the natural, annealed and quenched conditions. Where this has required separate figures for each condition (as in the case, for example, of the tension, impact and torsion tests), other figures have been prepared (Figs. 8, 12, 17, 23 and 27) in which curves for certain of the physical

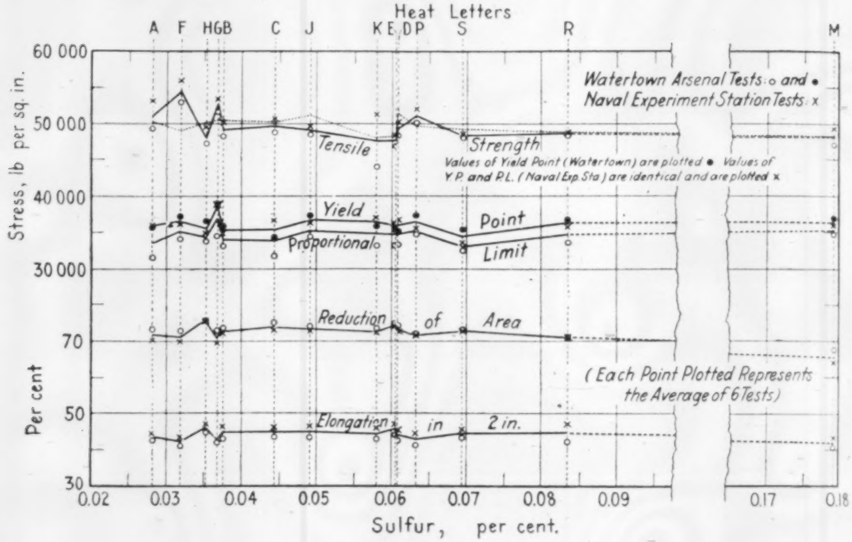

FIG. 5.—Tensile Properties of Rivet Bars in Natural Condition.

For explanation of dotted tensile strength curve, see text, p. 125.

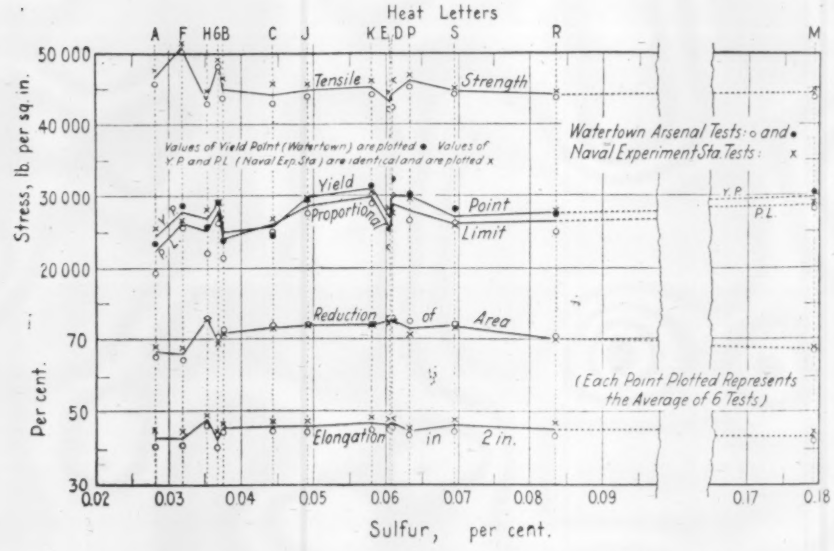

FIG. 6.—Tensile Properties of Rivet Bars in Annealed Condition.

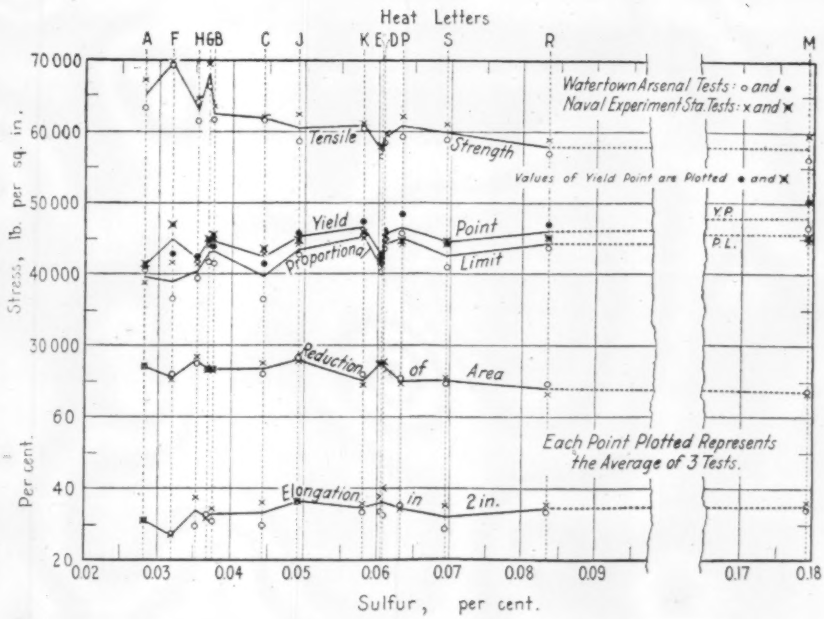

FIG. 7.—Tensile Properties of Rivet Bars in Quenched Condition.

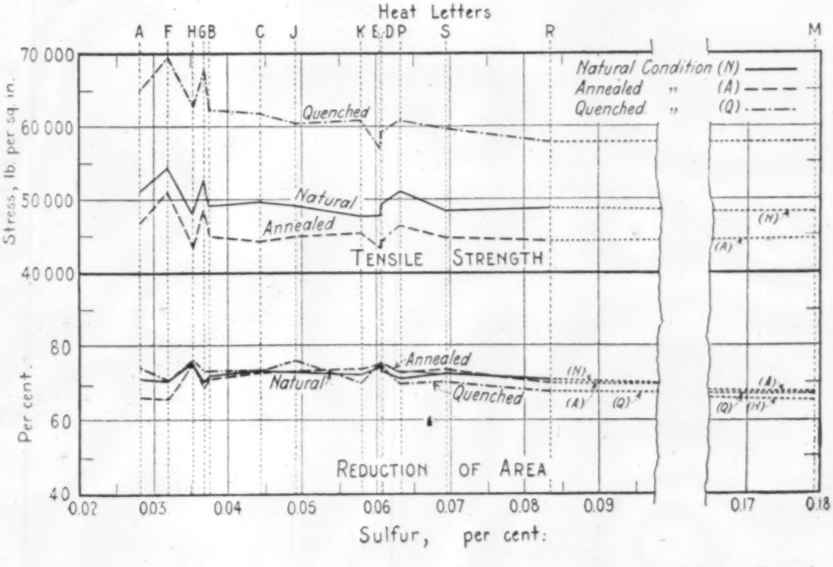

FIG. 8.—Comparison of Tensile Strengths and Reductions of Area of Rivet Bars in Natural, Annealed and Quenched Conditions. (Curves taken from Figs. 5, 6 and 7.)

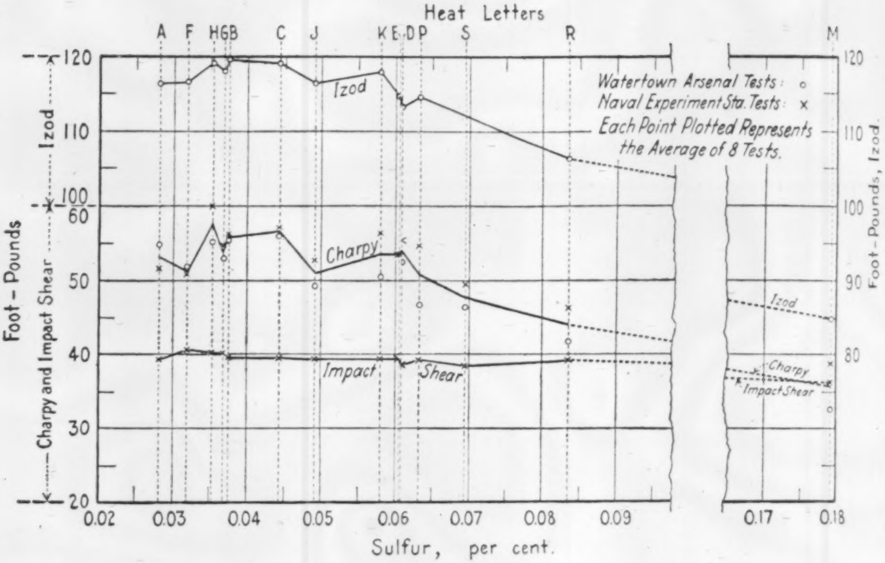

Fig. 9.—Impact Values of Rivet Bars in Natural Condition.

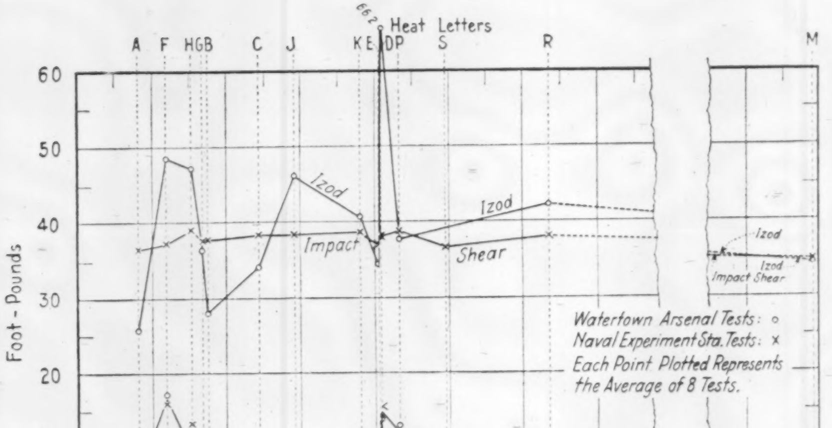

Fig. 10.—Impact Values of Rivet Bars in Annealed Condition.

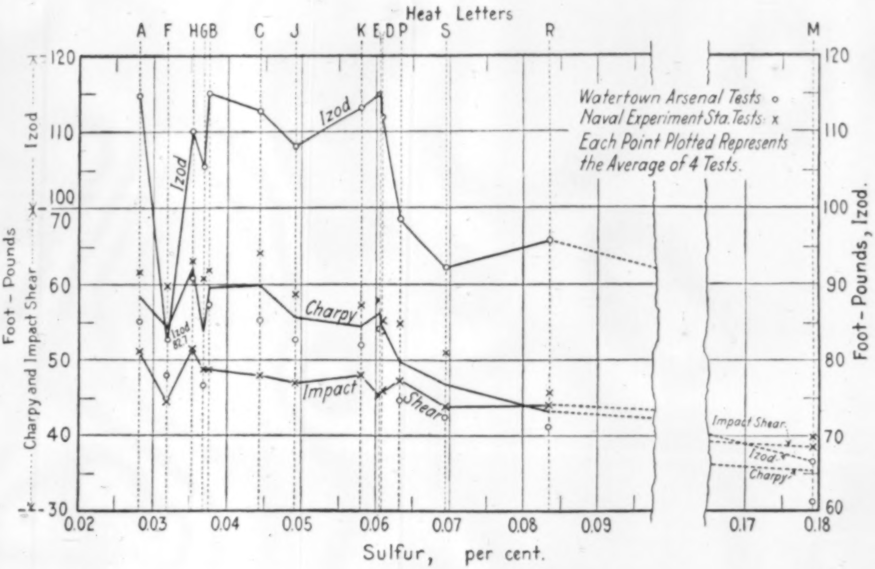

FIG. 11.—Impact Values of Rivet Bars in Quenched Condition.

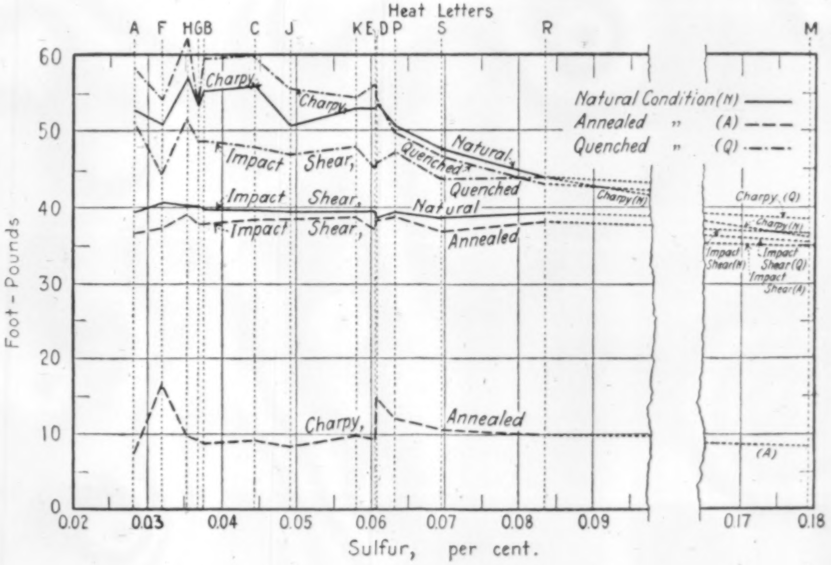

FIG. 12.—Comparison of Charpy and Impact Shear Values of Rivet Bars in Natural, Annealed and Quenched Conditions. (Curves taken from Figs. 9, 10 and 11.)

properties for the three conditions have been grouped for purposes of ready comparison.

The Committee wishes here to direct attention to the very satisfactory agreement of results obtained at the two laboratories.

TESTS OF RIVET BARS.

Tension Tests.—Typical stress-strain curves of tension specimens from the rivet bars are shown in Fig. 4. These are from bars taken from heat *C* (sulfur 0.0444) in the natural condition. They are typical of all the stress-strain curves obtained.

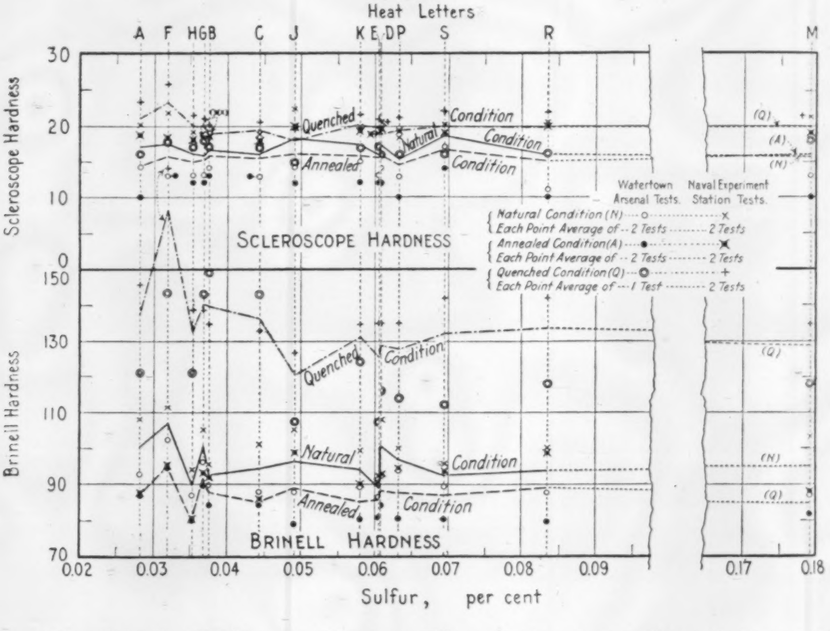

FIG. 13.—Brinell and Scleroscope Hardness Values of Rivet Bars in Natural, Annealed and Quenched Conditions.

The results of tension tests for material in the natural, annealed and quenched conditions are given in Figs. 5, 6 and 7, respectively. The properties plotted are proportional limit, yield point, tensile strength, elongation in 2 in. and reduction of area. Attention is called to the fact that the values of proportional limit and yield point reported by the Naval Experiment Station for material in the natural and annealed conditions (Figs. 5 and 6) are identical. The values of tensile strength and reduction of area for the three conditions are compared in Fig. 8.

Impact Tests.—The results of impact tests for material in the natural, annealed and quenched conditions are given in Figs. 9, 10 and 11, respectively. The properties plotted are Charpy impact values, Izod impact values and impact shear values. The Charpy and impact shear values for the three conditions are compared in Fig. 12.

Hardness Tests.—The Brinell and scleroscope hardness values for material in the natural, annealed and quenched conditions are plotted in Fig. 13.

Bend Tests.—None of the specimens from any heat, when tested in the natural and annealed conditions, failed when bent through 180 deg. flat. When tested in the quenched condition at Watertown Arsenal, one of the three specimens from heat *F* (sulfur 0.0317) cracked when bent in this way and one of the three specimens from heat *R* (sulfur 0.0834) also cracked; all of the other specimens in the quenched condition passed the test. None of the specimens tested in the quenched condition at the Naval Experiment Station failed in this test.

Torsion Tests.—The results of torsion tests for material in the natural, annealed and quenched conditions are given in Figs. 14, 15 and 16, respectively. The properties plotted are stress at proportional limit, stress at maximum torque, angle of twist per inch at proportional limit and angle of twist per inch at break. The percentage of elongation, the reduction of area and the shearing modulus of elasticity were also determined, but since they have no special significance they are not included in this preliminary report. The values of stress at maximum torque and angle of twist per inch at break for the three conditions are compared in Fig. 17.

Shear Tests.—The shearing strengths of the rivet bars for natural, annealed and quenched conditions are given in Fig. 18.

TESTS OF RIVETS.

Bend Tests.—All of the rivets tested in either natural or quenched condition passed the test, except two rivets from heat *M* (sulfur 0.1793) tested in the quenched condition at the Naval Experiment Station. These rivets had had the surface scale removed and failed at approximately 155 deg.

Flattening Tests.—All of the heads and shanks tested passed this test. In some cases a few minor surface cracks showed, but nothing in the nature of failure was observed.

Upsetting Tests.—All of the shanks tested passed the cold and hot upsetting tests. In the case of cold upsetting, a few small cracks developed, but nothing in the nature of failure was observed.

Tests on Riveted Joints.—The results of the tests on riveted joints are given in Fig. 19.

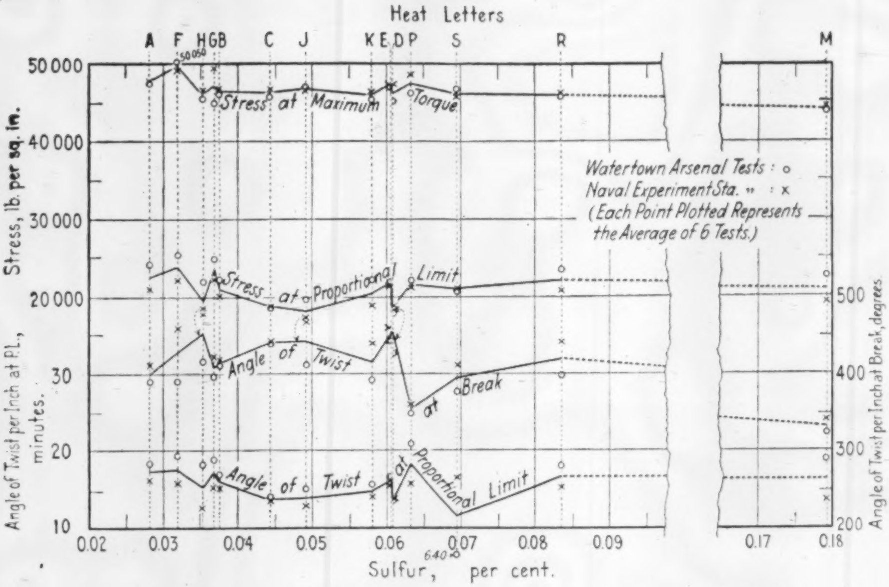

FIG. 14.—Torsional Properties of Rivet Bars in Natural Condition.

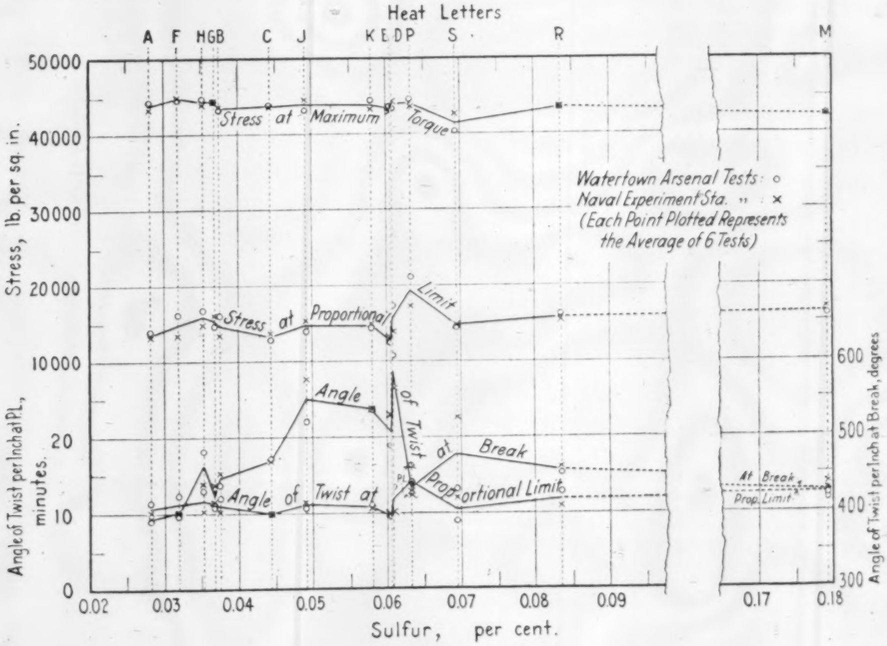

FIG. 15.—Torsional Properties of Rivet Bars in Annealed Condition.

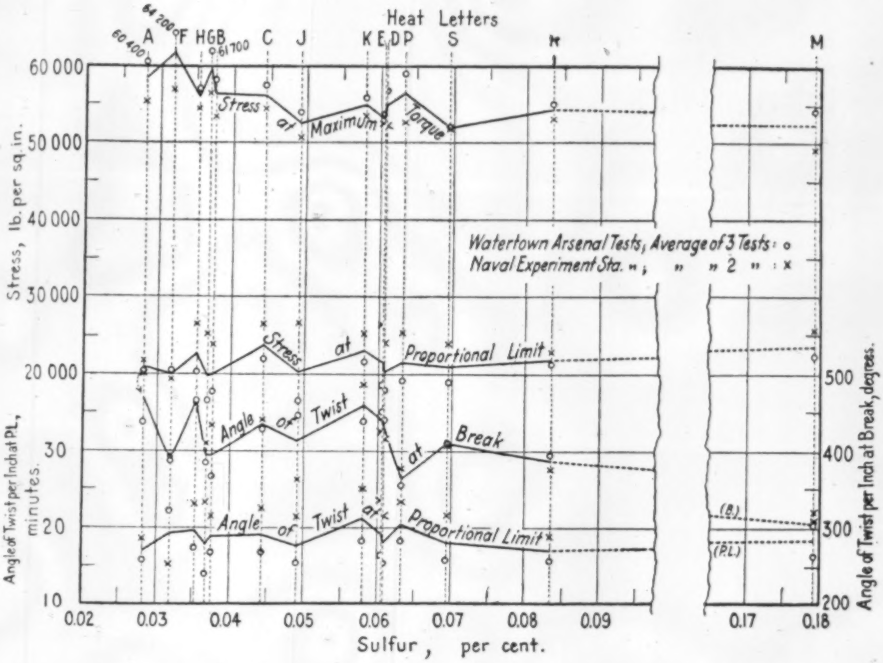

FIG. 16.—Torsional Properties of Rivet Bars in Quenched Condition.

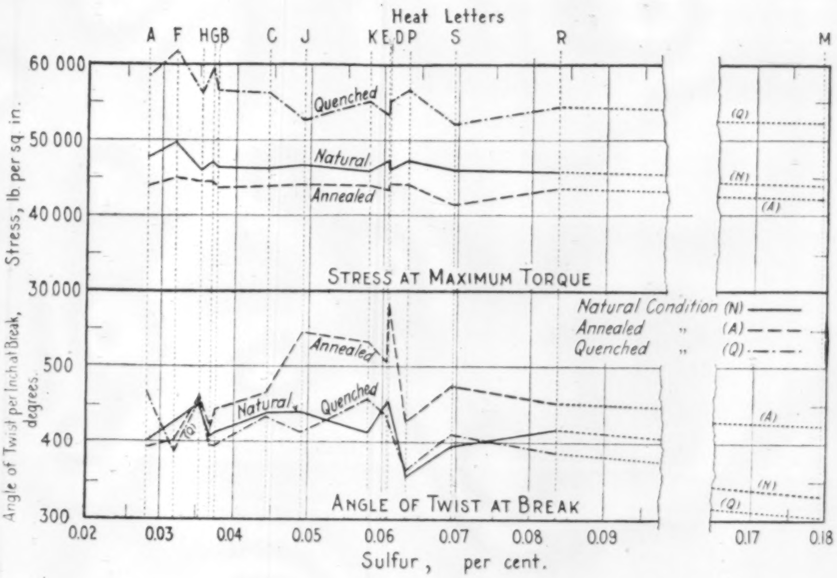

FIG. 17.—Comparison of Stresses at Maximum Torque and of Angles of Twist per Inch at Break of Rivet Bars in Natural, Annealed and Quenched Conditions. (Curves taken from Figs. 14, 15 and 16.)

TESTS OF "TRANSVERSE" MATERIAL FROM SLABS.

Tension Tests.—The results of tension tests for material in the natural, annealed and quenched conditions are given in Figs. 20, 21 and 22, respectively. The properties plotted are proportional limit, yield point, tensile strength, elongation in 2 in. and reduction of area. The values of tensile strength and reduction of area for the three conditions are compared in Fig. 23.

Impact Tests.—The results of impact tests for material in the natural, annealed and quenched conditions are given in Figs. 24, 25 and 26, respectively. The properties plotted are Charpy impact values, with impact both in the direction of and at right angles to the long dimension of the slab, and impact shear values, with impact also in these two directions. The Charpy and impact shear values, with impact in the direction of the long dimension of the slab, for material in the three conditions are compared in Fig. 27.

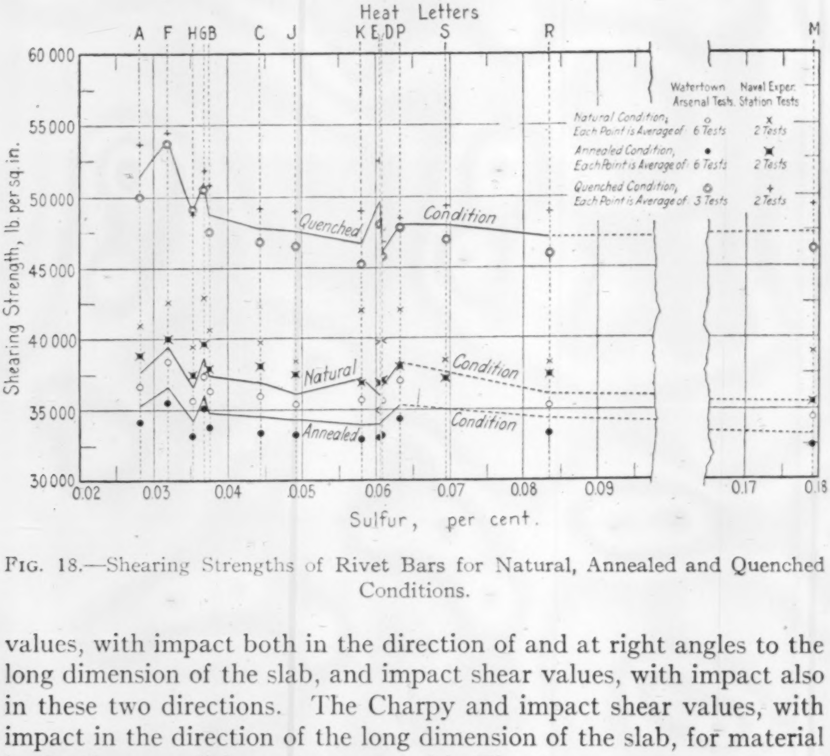

FIG. 18.—Shearing Strengths of Rivet Bars for Natural, Annealed and Quenched Conditions.

Hardness Tests.—The Brinell and scleroscope hardness values for material in the natural and annealed conditions are given in Fig. 28. No hardness determinations on the quenched material were made.

Bend Tests.—All of the specimens tested in the natural condition at Watertown Arsenal bent through 180 deg. flat without failure with the following exceptions: One of the three specimens from heat *R* (sulfur 0.0834) failed and two of the three specimens from heat *M* (sulfur 0.1793) failed. All of the specimens tested in the natural condition at the Naval Experiment Station passed save the two representing heat *M*, both of which failed.

All of the specimens tested in the annealed condition passed this test at both laboratories, except that two of the three specimens from heat *M* (sulfur 0.1793) tested at Watertown Arsenal failed.

Of the specimens tested in the quenched condition (at the Naval Experiment Station only), each of the two specimens from heats *K* (sulfur 0.0580), *P* (sulfur 0.0633), *R* (sulfur 0.0834), and *M* (sulfur 0.1793) failed; the specimens from all the remaining heats passed this test.

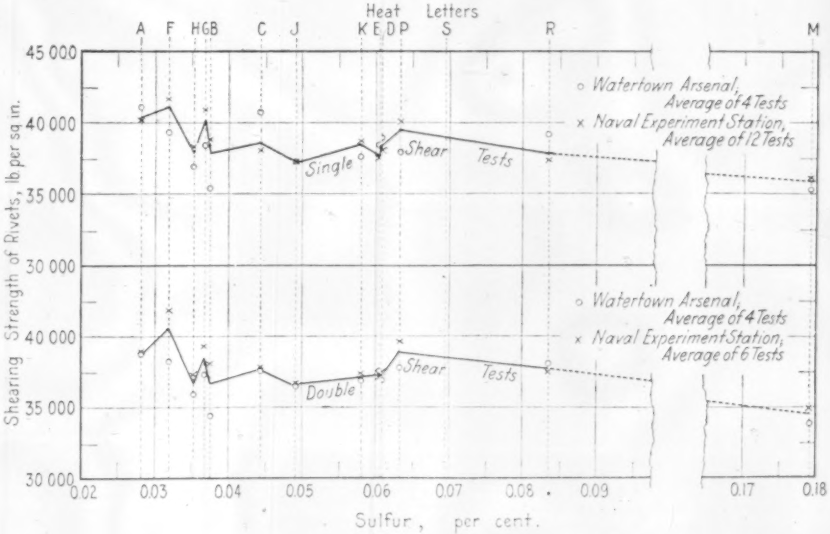

FIG. 19.—Tests of Riveted Joints. Shearing Strengths of Rivets from 13 Heats Tested in Single and Double Shear.

Shear Tests.—The shearing strengths of specimens in the natural, annealed and quenched conditions are given in Fig. 29.

DISCUSSION.

As has previously been stated, the Joint Committee, while it has reviewed all of the test data in this investigation, prefers to defer any extended discussion of the results and the drawing and publishing of formal conclusions therefrom. From its study of the data, however,

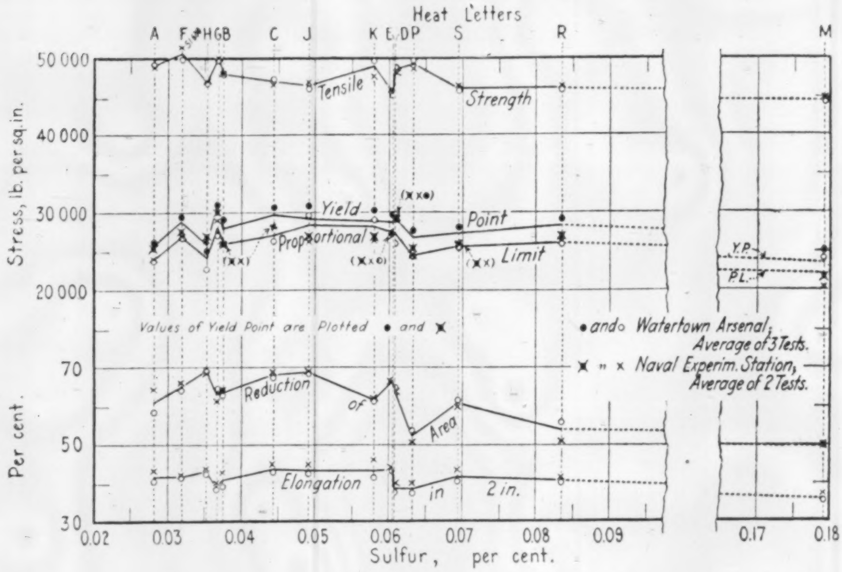

FIG. 20.—Tensile Properties of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Natural Condition.

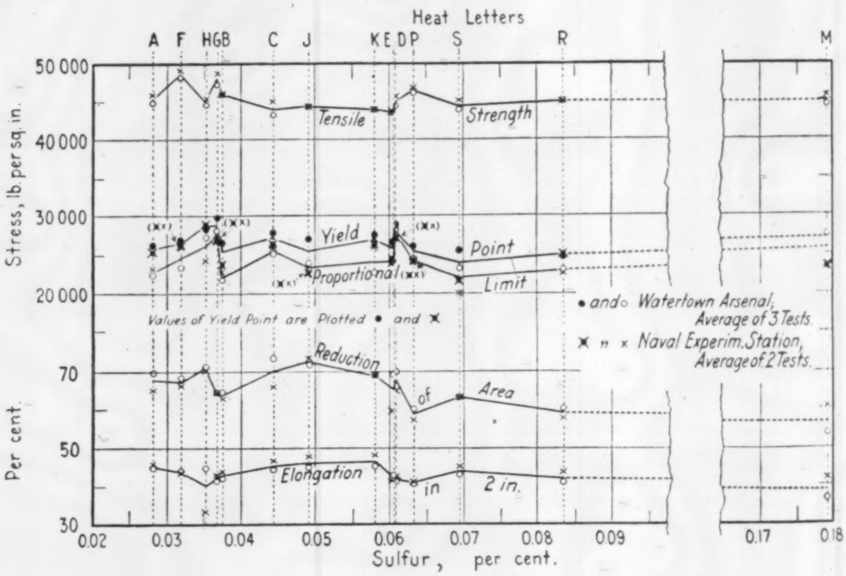

FIG. 21.—Tensile Properties of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Annealed Condition.

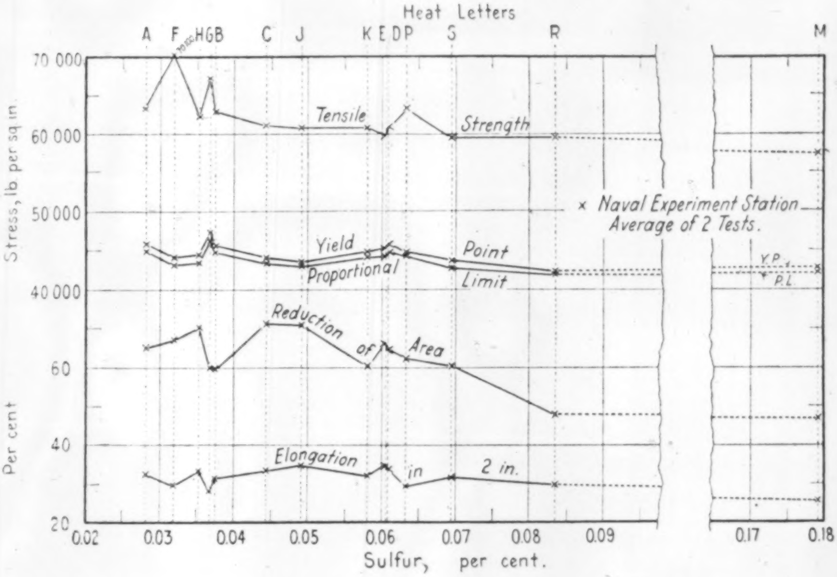

FIG. 22.—Tensile Properties of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Quenched Condition.

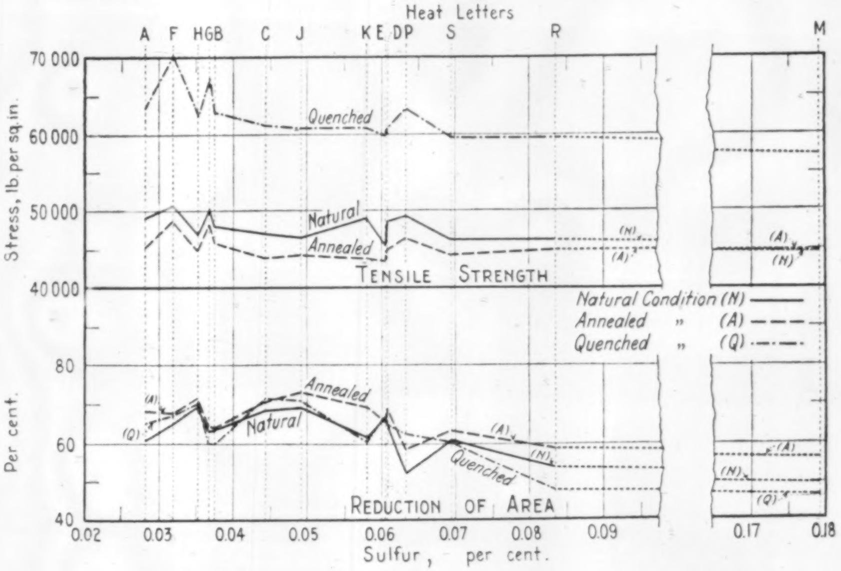

FIG. 23.—Comparison of Tensile Strengths and Reductions of Area of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Natural, Annealed and Quenched Conditions. (Curves taken from Figs. 20, 21 and 22.)

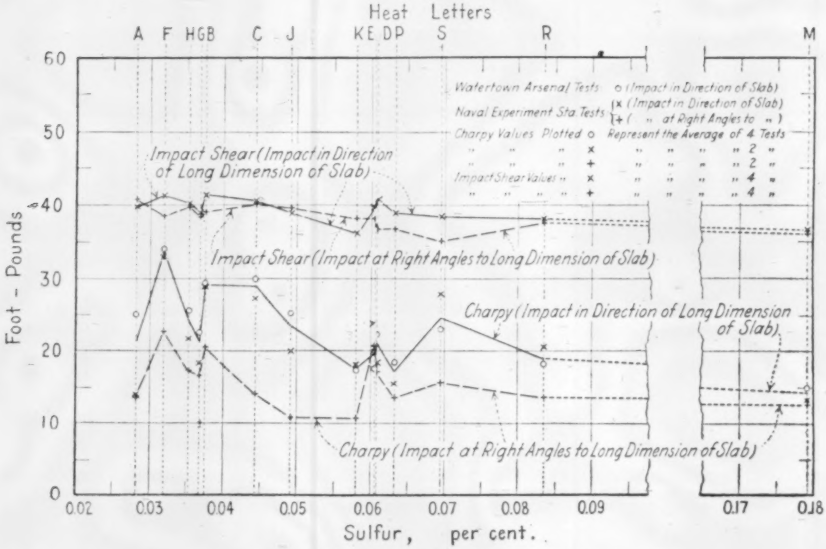

FIG. 24.—Impact Values of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Natural Condition.

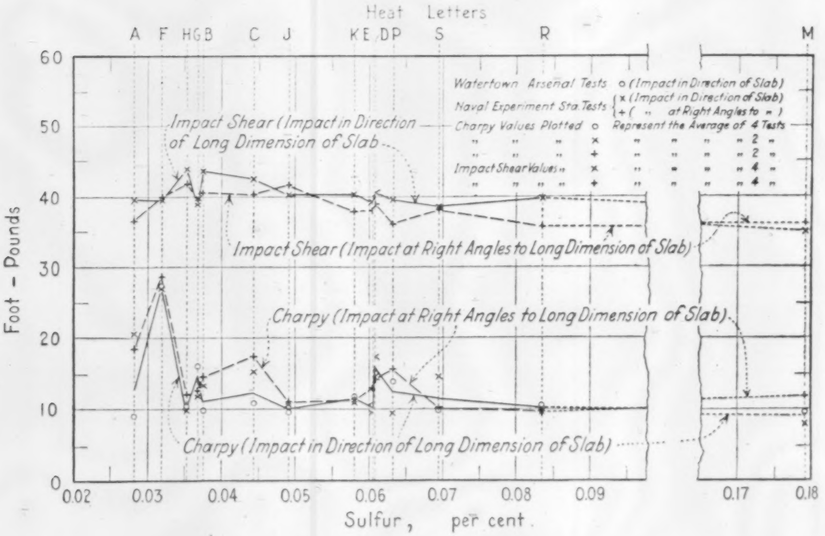

FIG. 25.—Impact Values of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Annealed Condition.

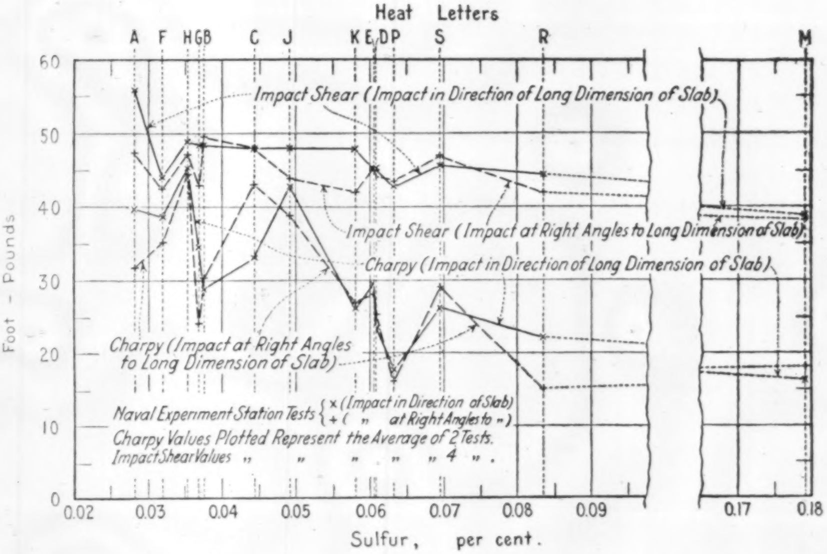

FIG. 26.—Impact Values of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Quenched Condition.

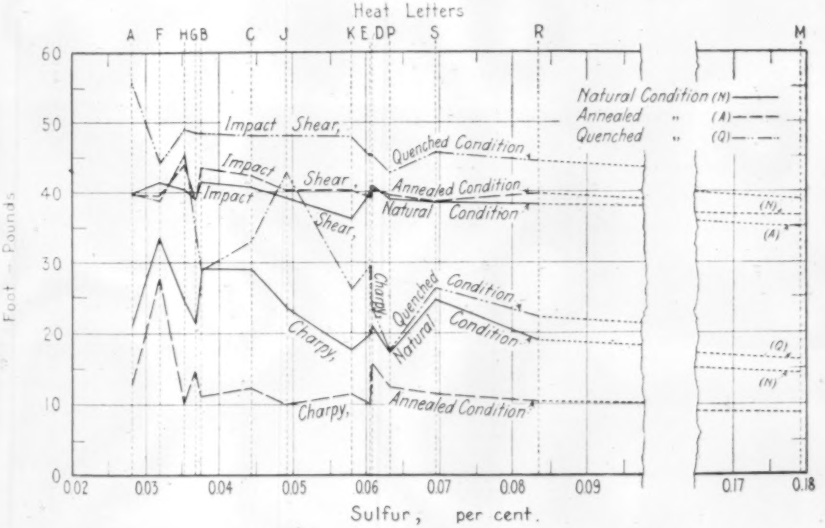

FIG. 27.—Comparison of Charpy and Impact Shear Values of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Natural, Annealed and Quenched Conditions. Impact in Direction of Long Dimension of Slab. (Curves taken from Figs. 24, 25 and 26.)

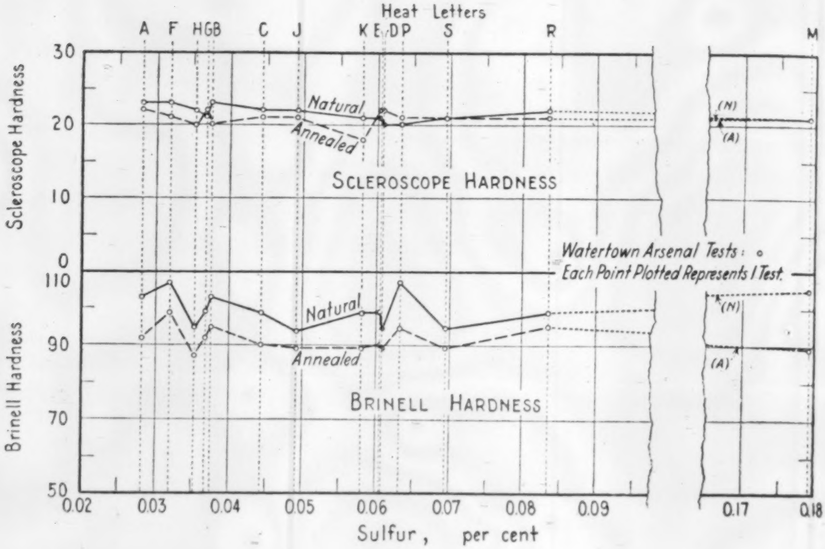

FIG. 28.—Brinell and Scleroscope Hardness Values of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Natural and Annealed Conditions.

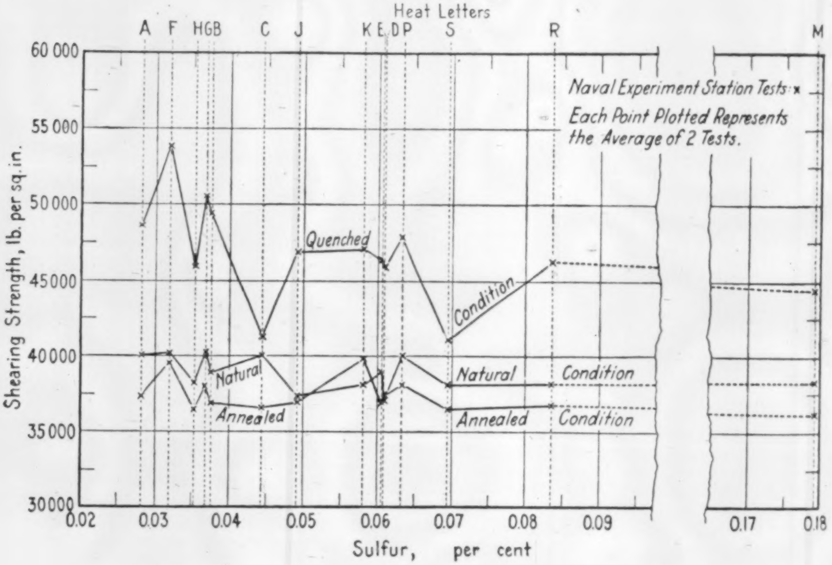

FIG. 29.—Shearing Strength of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Natural, Annealed and Quenched Conditions.

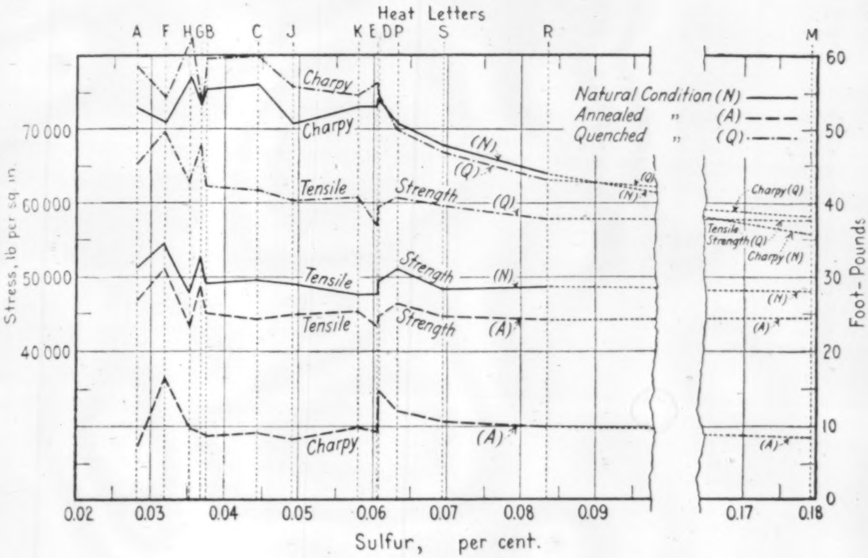

FIG. 30.—Comparison of Tensile Strengths and Charpy Impact Values of Rivet Bars in Natural, Annealed and Quenched Conditions. (Curves taken from Figs. 8 and 12.)

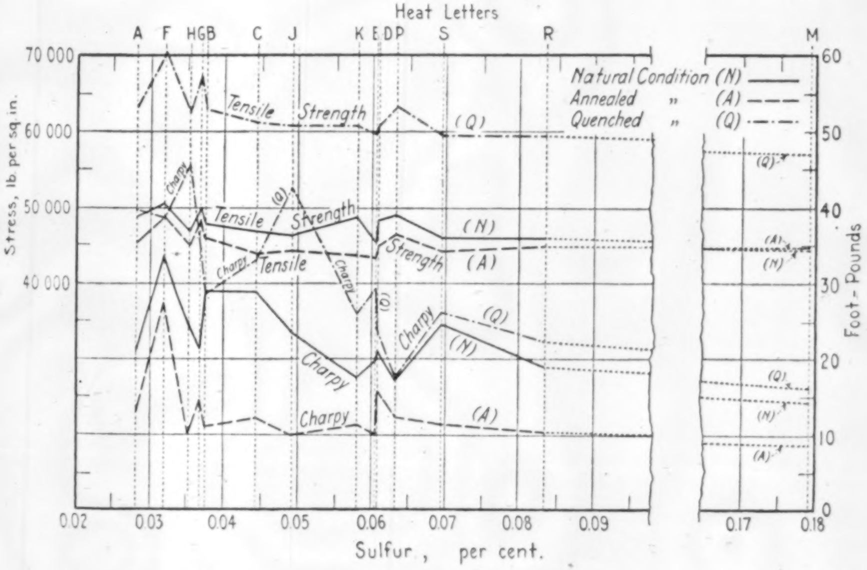

FIG. 31.—Comparison of Tensile Strengths and Charpy Impact Values of Rivet Steel. Specimens with Longitudinal Axes Perpendicular to Direction of Rolling. Material in Natural, Annealed and Quenched Conditions. (Curves taken from Figs. 23 and 27.)

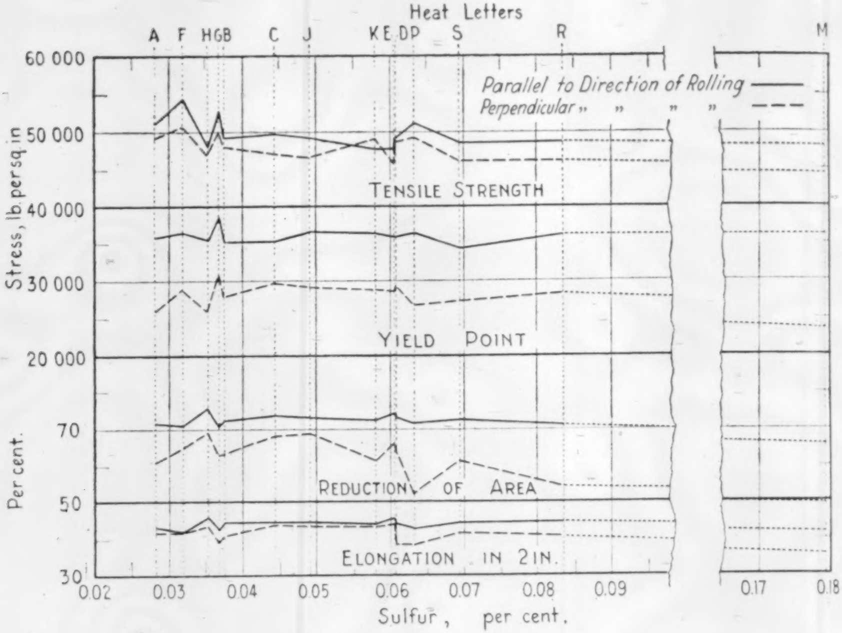

FIG. 32.—Comparison of Tensile Properties of Rivet Steel in Directions Parallel and Perpendicular to Direction of Rolling. Material in Natural Condition. (Curves taken from Figs. 5 and 20.)

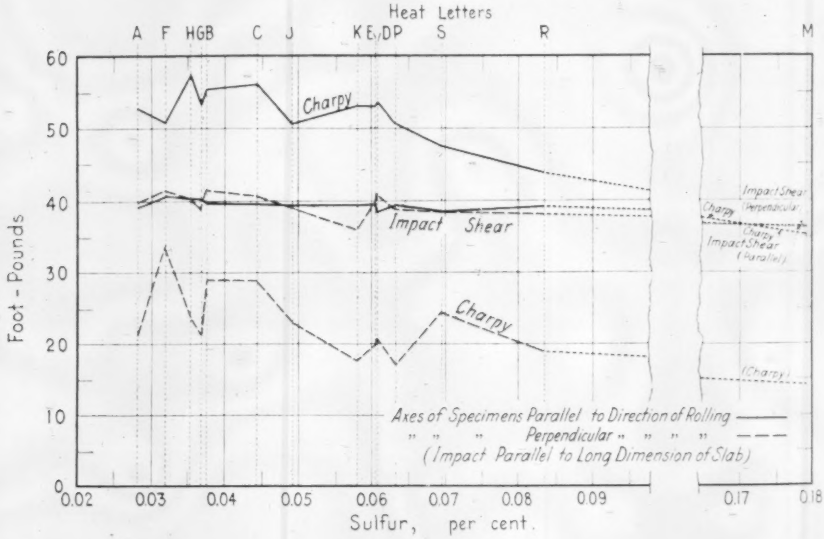

FIG. 33.—Comparison of Charpy and Impact Shear Values of Rivet Steel in Directions Parallel and Perpendicular to Direction of Rolling. Material in Natural Condition. (Curves taken from Figs. 9 and 24.)

the Joint Committee has realized the possibilities that exist for comparative study of the various properties herein reported. While the sole purpose of the Committee in this report is to present the test data in as concise and convenient form as possible, there is some advantage in including four additional figures for the convenience of those who desire to study the data presented. These figures are suggestive of the possibilities of further study.

In Fig. 30 are compared the tensile strengths and Charpy impact values of the rivet bars tested in the natural, annealed and quenched conditions, the curves being taken from Figs. 8 and 12.

In Fig. 31 are compared the tensile strengths and Charpy impact values of specimens whose axes are perpendicular to the direction of rolling of the slab, tested in the natural, annealed and quenched conditions. These curves are taken from Figs. 23 and 27.

In Fig. 32 are compared the tensile properties of material tested parallel and perpendicular to the direction of rolling, the material in each case being in the natural condition. These curves are taken from Figs. 5 and 20.

In Fig. 33 are compared the Charpy and impact shear values of specimens whose axes are parallel and perpendicular to the direction of rolling, the material being tested in the natural condition. These curves are taken from Figs. 9 and 24.

Similar figures comparing other properties for the materials in the different conditions and tested in the two directions may readily be plotted from the data submitted.

An examination of the tensile strength curves shows clearly the effect of the carbon and manganese contents of certain heats that are considerably above or below the average percentages of these elements. It was accordingly determined to plot a "corrected" tensile strength curve from the data in Fig. 5, which gives the average tensile strengths of rivet bars tested in the longitudinal direction in the natural condition. The "corrected" tensile strengths were obtained from the average tensile strengths reported by deducting or adding (as required) a number of pounds per square inch corresponding to the differences between the actual carbon, manganese and phosphorus contents of each heat and the averages of those elements for each heat. The factors adopted for making these corrections were:[1]

770 lb. per sq. in. for each 0.01 per cent of carbon;
1000 lb. per sq. in. for each 0.01 per cent of phosphorus;
y[1] lb. per sq. in. for each 0.01 per cent of manganese.

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[1] These values are taken from Campbell's formula for basic steel. See "The Manufacture and Properties of Iron and Steel," H. H. Campbell, Fourth Edition, p. 391. The values of "y" corresponding to each 0.01 per cent of manganese are given in Table XVII–V, p. 381 of Campbell's book.

The committee does not feel that there are sufficient authoritative data available to make corresponding corrections for the material in the annealed and quenched conditions and for material tested transversely to the direction of rolling. Also, there are not authoritative data available for correcting the other physical properties, such as impact values, hardness, etc.

METALLOGRAPHIC STUDY.

A metallographic study of this material has been made by the Joint Committee and will be reported in the later complete publication.

Respectfully submitted on behalf of the Joint Committee,

GEORGE K. BURGESS,
Chairman.

C. L. WARWICK,
Secretary.

DISCUSSION.

Mr. Unger.

MR. J. S. UNGER (*presented in written form*).—For more than 40 years, the question of the effect of sulfur in steel has attracted the attention of metallurgists. Much study has been given to this subject, extending so far as to include the several chemical forms or combinations in which it exists, particularly in cast iron.

Within a period of 20 years, the tonnage of steel made by the two principal processes, the bessemer and the basic open-hearth, has undergone a great change. In 1900, about 65 per cent of the total tonnage was bessemer, in 1920, 25 per cent.

With the change in processes came a change in the sulfur content in steel, the average sulfur in bessemer steel being at least 0.065, against 0.040 per cent in the basic open-hearth. Structures of all kinds built from 20 to 40 years ago of bessemer steel, are still in service today, being one of the best evidences that steel may contain a considerably higher percentage of sulfur than is permissible in present basic open-hearth steel specifications, and still give years of excellent service.

Additional evidence is found by making a study of soft, medium and hard steel parts, which have worn out in service, giving a good life, and which in many cases have contained more than 0.065 per cent of sulfur. On the other hand, equally convincing evidence is found for the same kinds of steels failing after a short time in similar service, in which the sulfur has been under 0.040 per cent. Evidence of the above kind is enough to make one hesitate in forming an opinion whether a reasonable amount of sulfur, say under 0.100 per cent, is detrimental or otherwise. These facts conflict with the generally accepted opinion that steel is of poor quality and should not be used for any important work, unless it be low in sulfur. I sincerely hope the committee will give this angle of their work serious consideration in their future studies.

In discussing the committee's preliminary report, I have copied graphs from their report, combining a number of their graphs in a single figure and inserting a line for sulfur in order that it may be more easily and quickly comprehended. In this chart, Fig. 1, I have shown the composition curves for carbon and manganese at the bottom, adding a line for the sulfur content. Since the ordinates and abscissas are in percentages of sulfur, the line for sulfur becomes a gradually rising straight line.

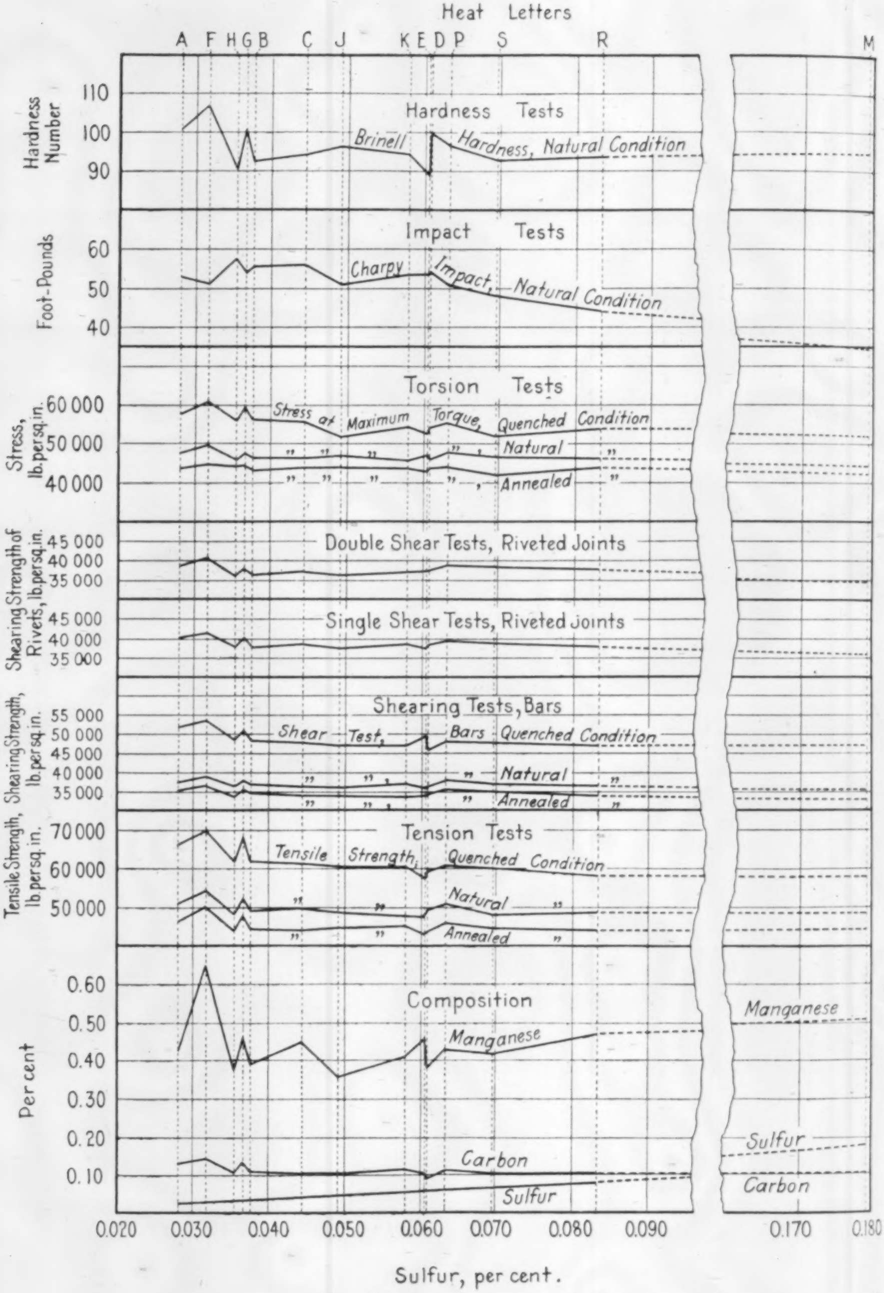

FIG. 1.—Comparison of Composition Curves with Curves for Various Tests.

Mr. Unger. The effect of the carbon and manganese in the several heats is clearly shown by the approximate parallelism of the composition curves with those representing the strength in tensile, shearing, torsion and impact and with the hardness curves. All the curves for the physical properties are not shown as there is not sufficient space.

The striking thing in the chart seems to be that changes in the carbon and manganese content are immediately reflected by similar changes in the physical properties of the several heats with little, if any, change due to the increasing sulfur. It is almost impossible to make a number of heats of steel containing exactly the same percentage of carbon and manganese. Since this is true, it is practically impossible to determine the effect of sulfur if other variables in composition exist in the steel.

In studying this same problem during 1915, I believed it best to use the same heat of steel, but to vary the sulfur content in the individual ingots of the heat. My results were given in full in a paper before the Society of Automotive Engineers, in January, 1916, and later in a paper before the American Boiler Manufacturers, in June, 1916.

Many persons are inclined to believe that sulfur added to steel does not have the same effect as residual sulfur remaining in the steel, but it is surprising how closely my results, obtained by added sulfur, check the results of the committee's work with residual sulfur, when allowances are made for the effects of the variations in the carbon and manganese in the several heats.

The committee's work was confined to rivet steel, but this same quality steel is used in making wire products, tubular products and sheets. The specifications for such products specifies the composition and sometimes calls for tensile tests and bending tests. The fitness of the steel is determined by the working of steel during fabrication and by such shop tests as flattening, bending, hydrostatic or beading tests. On pages 102, 103, 104 and 113 of the report, some shop tests were made, showing very little differences among the steels. These are some of the commercial tests employed by the user to show whether the steel is of good quality, yet the committee, beyond stating what was done, have not made any comment on the quality. Instead, physical or mechanical tests of many kinds were made, very few of which are ever regularly used in the arts, and the graphs presented to show the quality.

I have examined the complaints or claims for rivet steels covering a period of 11 years from 1911 to 1922. They show the following percentages:

Mr. Unger.

For Quality.—		
Mixed steel, and tensile strength	15	per cent
For Surface.—		
Mechanical Defects, Seams, Pipe, Split Heads	28	"
For Rolling.—		
Out of Round Variation in Size	6	"
For High Sulfur	51	"
Total	100	"

This table shows that more than one-half of the complaints were due to high sulfur, in most cases causing the rejection of the steel without any effort being made on the part of the user by shop or service tests to see if the steel was really bad or unfit for use.

The committee has refrained from drawing conclusions from their work. The graphs are not easily understood by the layman. Considerable time has elapsed since the work was begun. Probably a much longer time will be needed for the study of the medium and harder varieties of steel. In the meantime, much commercially good steel is being thrown away. The producer and consumer are awaiting the verdict.

I ask the committee to hasten their work, drawing conclusions as they proceed and completing the work at an early date. This will be of great benefit to our Society, settling, partially at least, a controversy of many years standing.

Mr. Burgess.

MR. G. K. BURGESS (*Chairman of Joint Committee on Investigation of Phosphorus and Sulfur in Steel*).—I was very glad indeed to see that Mr. Unger brought before this meeting a summary of the work which he did several years ago. I think the demonstration that he has made is highly convincing. It is the object of the committee, primarily, in undertaking this investigation to secure data on an impartial basis. I have not any criticism or remark to make on the actual contribution that Mr. Unger has made to the work of the committee. I agree with him entirely in all he said, that there was more work for the committee to do; and I can say also regarding haste and speed in hurrying up the report, that I will do my best, and the committee I am sure will also, to get the report in permanent form as soon as possible as a technologic paper of the U. S. Bureau of Standards.

REPORT OF COMMITTEE A-2

ON

WROUGHT IRON.

During the year Committee A-2 has held three meetings.

Various small, though in some cases important, modifications of present standards have received attention.

A slight change, as indicated below, in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 21) is intended to define more closely the high grade material desired. The correction of an accidental error in table headings is also necessary because the specifications do not cover the coating of galvanized pipe.

There has been some feeling in the committee that our Standard Specifications for Wrought-Iron Forgings for Locomotives and Cars (A 73 – 18) does not measure up fully to the present state of manufacture of the high grade material needed for the use indicated. A modification of the ductility requirements is therefore offered to meet this need.

Some difficulty has been experienced in connection with the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 21 T). In the case of lap-welded wrought-iron tubes having very heavy walls, particularly those over No 6. gage, it is found that the flattening test is too severe if the weld is placed at the point of maximum bend. A modification of this requirement is therefore presented. The interpretation of the results of the crushing test is assisted by the addition of a sentence under that heading. When these specifications were written, the limit for the flange test of wrought-iron tubes was a subject for much discussion and that specified was not satisfactory to all interested. It is now desired to increase the requirements of this test in order to insure a better grade of material.

The tentative specifications were originally prepared by Committees A-1 and A-2 jointly. Committee A-1 on Steel has not acted upon the recommendations for revision suggested by Committee A-2 but since the requirements that are being revised affect iron tubes only, the approval of Committee A-1 is anticipated.

During the year, the Tentative Specifications for Merchant Bar Iron (A 85 – 21 T) have been discussed by representatives of the producers, who have, however, proposed no changes.

Members of the committee are cooperating with Committee A-4 on Heat Treatment of Iron and Steel in a proposed investigation of the annealing of wrought-iron hoisting chains.

PROPOSED REVISIONS OF STANDARDS.

1. *Specifications for Welded Wrought-Iron Pipe (A 72 - 21)*.[1]—The following revisions are recommended:

Section 3. (*a*)—Change the words "puddled pig iron" to read "all pig puddled iron."

Omit the words "Black and Galvanized" from under the titles of Tables I and II.

The letter ballot vote of the committee on these recommendations is as follows: Affirmative, 28; negative, 0; not voting, 12.

2. *Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 - 18)*.[1] It is recommended that these specifications be revised as follows:

Section 6. (*a*)—Change the requirements given in the table included in Section 6 (*a*) from their present form: namely,

Tensile Strength, lb. per sq. in.	45 000
Yield Point, lb. per sq. in.	0.5 tens. str.
Elongation in 4 in., per cent	22
Reduction of Area, per cent	30

to read as follows:

	BLOOMS.	FORGINGS, CLASSES A AND B.
Tensile Strength, lb. per sq. in.	45 000	45 000
Yield Point, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 4 in., per cent	22	24
Reduction of Area, per cent	30	33

The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 30; negative, 0; not voting, 10.

REVISIONS OF TENTATIVE STANDARDS.

3. *Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 - 21 T)*.[2]—The following revisions in these specifications are recommended:

Section 6. (*a*)—Change the third sentence to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

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[1] 1921 Book of A.S.T.M.Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 461 (1921).

"Within these limits the width of flange shall be not less than [10] *12½* per cent of the outside diameter for charcoal-iron, nor less than 15 per cent for steel tubes up to 2½ in., inclusive."

Section 7. (*b*)—Change the Note at the end of Section 7 (*b*) to read as follows:

"In the case of lap-welded wrought-iron tubes thicker than No. 6 B. w. g. (0.203 in.), the test shall be made with the weld 45 deg. away from the point of maximum bend. For other wrought-iron tubes and for all steel tubes covered by this section, the test shall be made with the weld at the point of maximum bend."

Section 8.—At the end of Section 8, to the paragraph applying to charcoal-iron tubes, add the words "slight surface checks shall not be a cause for rejection."

The letter ballot vote of the committee on these recommendations is as follows: Affirmative, 29; negative, 3; not voting, 8.

This report has been referred to letter ballot of the committee, which consists of 40 members, of whom 32 have voted affirmatively, none negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. E. SMITH,
Chairman.

J. B. YOUNG,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Standard Specifications for Welded Wrought-Iron Pipe and of the Standard Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars were accepted for publication as tentative and appear on pages 983 and 984, respectively.

The proposed revisions of the Tentative Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes were accepted. The tentative specifications as thus revised appear on page 553..

REPORT OF COMMITTEE A-3

ON

CAST IRON.

Considerable work has been done by Committee A-3 during the past year. While revised specifications for cast-iron car wheels were submitted as tentative at the annual meeting of the Society last year, the committee has nevertheless continued work on the subject and this year presents a further revision of the car-wheel specifications as the result of this study and the very wide discussion of the cast-iron wheel throughout the country. The tentative specifications have been rewritten and are appended hereto in their proposed revised form.[1] The committee recommends that they be accepted for publication as tentative in place of the present Tentative Specifications for Cast-Iron Car Wheels (A 46 - 21 T).[2] The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 28; negative, 3; not voting, 22.

Committee A-3 further submits revised specifications for foundry pig iron. The present Standard Specifications for Foundry Pig Iron (A 43 - 09),[3] adopted in 1904 and revised in 1909, have been brought up to date by making a few changes found desirable as experience was acquired. Revised specifications are appended,[4] and the committee recommends that they be accepted by the Society for publication as tentative to replace, when adopted, the present standard specifications. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 41; negative, 3; not voting, 9.

New specifications are presented herewith to cover what the committee has classified as "high-test" cast iron to include those irons which show higher strengths than the usual run of material. In the production of these cast irons, considerable steel scrap is added to the mixtures, and with a high degree of metallurgical skill the foundryman is able to turn out exceptionally good metal. In order to differentiate this high-grade material from the lower ranges of castings, none the less good in their class, these new specifications have been prepared to enable the consumer of castings to call for a superior article and to give him some assurance that he will get it. These specifications, under consideration for several years, are appended hereto,[1] and it is recommended that the Society accept them for publication as tentative. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 41; negative, 2; not voting, 10.

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[1] See p. 569.—Ed.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 481 (1921).

[3] 1921 Book of A.S.T.M. Standards.

[4] See p. 566.—Ed.

There has also been much activity in the fields of cast-iron water pipe and pipe suitable for culverts. These matters will lead to either new specifications under joint committee auspices, or revision of existing specifications. Work has also been done on the study of test bars as suited for international purposes, but this is not far enough along as yet to enable reporting. The study of the effect of annealing on the strength of cast iron is also under way.

Much progress has been made on the study of molding sands under joint action of interested bodies, and other investigations by joint committees of the Society indicate several new specifications ahead in which Committee A-3 on cast iron is taking part.

This report has been submitted to letter ballot of the committee, which consists of 53 members, of whom 44 have voted affirmatively, none negatively, and 9 have refrained from voting.

Respectfully submitted on behalf of the committee,

RICHARD MOLDENKE,
Chairman.

GEO. C. DAVIES,
Secretary.

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[1] See p. 575.—ED.

[For a discussion of this report, see page 137.—ED.]

ADDENDUM TO REPORT OF COMMITTEE A-3.

At a meeting of Committee A-3 held on Monday, June 26, 1922, prior to the presentation of its annual report to the Society, revisions were recommended to be made in the proposed Tentative Specifications for Chilled Cast-Iron Wheels, as preprinted, as follows:

Section 2 (a).—Change the Sulfur requirement from 0.17 to 0.18 per cent.

Section 2 (c).—Omit this section reading as follows:

> "It is desired that the phosphorus content shall not exceed 0.30 per cent."

Section 15.—Change the Note following Section 15 of the specifications from its present form, namely:

> "The chill and physical tests specified only cover 33-in. wheels of the weights listed; other diameters and weights shall be in proportion."

to read as follows:

> "The chill and physical tests specified only cover 33-in. wheels of the weights listed. Requirements for wheels of other sizes are to be supplied by the committee."

Respectfully submitted,

RICHARD MOLDENKE,
Chairman.

GEO. C. DAVIES,
Secretary.

EDITORIAL NOTE.

The proposed Tentative Specifications for Chilled Cast-Iron Wheels referred to in this report and as amended in the Addendum to this report were accepted for publication as tentative and appear on page 569 as a revision of the Tentative Specifications for Cast-Iron Car Wheels.

The proposed revisions of the Standard Specifications for Foundry Pig Iron were accepted for publication as new tentative specifications and appear on page 566.

The proposed Tentative Specifications for High-Test Gray-Iron Castings referred to in this report were accepted for publication as tentative and appear on pages 575.

DISCUSSION.[1]

DISCUSSION ON SPECIFICATIONS FOR WHEELS.

[In presenting the Addendum to the Report of Committee A-3, Mr. Moldenke called on Mr. J. C. Ramage to explain the revisions contained therein of the proposed Tentative Specifications for Chilled Cast-Iron Wheels (Serial Designation: A 46 - 22 T), as preprinted.—Ed.]

Mr. Ramage.

MR. J. C. RAMAGE.—The first change relates to the phosphorus requirement of the proposed tentative specifications. These provide, Section 2 (*c*), "It is desired that the phosphorus content shall not exceed 0.30 per cent." This requirement was a topic of considerable discussion at the last annual meeting of the Society. The original reason for limiting the phosphorus was the detrimental effect it was thought this element had on the resistance of wheels to cracking under thermal expansion stresses. To more definitely develop this effect it was suggested that so-called repeated thermal tests be made, that is, that representative wheels be subjected to the standard thermal test, allowed to become cold, and then again subjected to the same test, the cycle to be repeated until the wheel cracked or broke. Acting on this suggestion, committee members have tested some twenty-five or more representative wheels, subjecting each individual wheel to the thermal test at least twenty times. Much to the surprise of most of us, only in one out of a total of five or six hundred tests, did a wheel crack and in that one case the wheel happened to be a low phosphorus wheel. In view of these results, the committee felt that the available data did not warrant further committing the Society to the low phosphorus requirement referred to and as a result voted to eliminate entirely Section 2 (*c*).

The second change relates to the sulfur limitation. The proposed sulfur limit of 0.17 per cent maximum, like a great many other limitations, was a compromise between suggested higher and lower limits. However, records of a large number of tests submitted to the committee by the Association of Manufacturers of Chilled Car Wheels, apparently indicated that sulfur up to around 0.18 per cent did not injuriously affect the strength of the wheel. This and the further fact that if the

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[1] The Report of Committee A-3 on Cast Iron was discussed jointly with the paper on "The Physics of Cast Iron and its Bearing on All Cast-Iron Products and Specifications for Cast Iron" by William R. Webster, Part II of the *Proceedings*, p. 217.—ED.

Mr. Ramage. sulfur was limited to 0.17 per cent it would throw out an appreciable number of otherwise good wheels, led the committee to the conclusion that everything considered it would be preferable to restore the 0.18 per cent sulfur limitation of the tentative specifications submitted last year.

The third so-called change is not a change but more in the nature of an explanation. The specifications as drawn cover all sizes and practically all weights of wheels. However, as the specifications themselves make clear, the chill and physical test requirements given refer only to 33-in. wheels of the weights listed—tests for other diameters and weights being specified only as to be in proportion thereto. The committee appreciates that this clause is a little indefinite but even so believes it better to allow it to remain in the specifications with the understanding and explanation here made that they are at work on a table giving specific requirements for other weights and diameters of wheels covered by the specifications and which table they hope to be able to present another year.

Mr. Job. MR. ROBERT JOB.—In connection with the proposed specifications, it may be of interest to mention one or two matters particularly in connection with the drop test. Under the plan proposed, the idea is to have a drop weighing 250 lb. Under the present specifications the weight of the drop is 200 lb. This, we found in practice, never told us anything, and it is a matter of record, I think, during the past twenty or thirty years, or whatever the time is since the method has been in use, that no rejection has ever taken place under the drop test with a 200-lb. drop, so that evidently it was necessary to have a method which would really differentiate between different grades of iron; consequently various tests were made by the different members of the committee, and also by others. In connection with this work on the Lehigh Valley for some months past all of our tests have been made with a 400-lb. weight, the idea being simply to gather together information that might be available for the use of the committee. The height of the drop was, with a 650-lb. wheel, 8 ft.; with a 700-lb. wheel, 9 ft.; and with a 750-lb. wheel, 11 ft. Under these tests with the 650-lb. wheel, we found it took on an average of about six blows to break the wheel, the minimum, I think, being five blows. With the 700-lb. wheel and with a 9-ft. height of drop, we found that it required say eight blows to break the wheel, and with the 750-lb. wheel, with a height of 11 ft., it required about six blows to break it. This gives you a very good idea of the resistance of the metal to the 400-lb. drop. As to the exact weight of the drop, I think nothing has been definitely decided. The committee in drawing up the present proposed specifications, placed the weight at 250 lb. This was done in a tentative way, not because it was the best weight to have, but simply to record progress, and it is quite possible that in view of the results which the different members have been gathering together, it may be thought desirable to gradually change the height, or the weight of the drop, depending upon the results which are obtained. **Mr. Job.**

MR. J. R. ONDERDONK.—With the present weight of the wheel, the 200-lb. drop seems almost like a tack hammer, as possibly the 400-lb. weight seems like nothing more than a machinist's hammer. Wheels have gone up now in weight to 950 lb., and some we recently broke, after giving them 200 odd blows with a 300-lb. weight at 15 ft., by giving them two more blows of a 1500-lb. weight at 20 ft. I agree with the previous speaker that the present weight is probably very inadequate to test out the present cast-iron wheels, and especially where we have gone up even over 750 and as high as 950 lb. **Mr. Onderdonk.**

THE CHAIRMAN (MR. G. K. BURGESS).—I may state also, as a matter of information to the Society, that at the U. S. Bureau of Standards we have begun a series of experiments on the physical properties at ordinary and elevated temperatures of cast iron of car wheel composition. **The Chairman.**

[The motion to accept the proposed Tentative Specifications for Chilled Cast-Iron Wheels for publication as tentative, revised as indicated in the Addendum to the report of the committee, was approved.—ED.]

DISCUSSION ON PROPOSED TENTATIVE SPECIFICATIONS FOR FOUNDRY PIG IRON.

[At this point, Mr. Moldenke presented on behalf of Committee A-3 the proposed Tentative Specifications for Foundry Pig Iron with the recommendation they be accepted for publication as tentative.—ED.]

MR. R. A. BULL.—Carrying out the thought that Mr. Moldenke has expressed in his appendix to Mr. Webster's paper with reference to the future adoption of specifications for pig iron for gray iron, malleable iron and steel foundry practice, it seems to me that it might be well to adopt a different caption. We all understand, of course, what the term foundry pig iron has meant commercially, but the word "foundry" now does not mean the gray iron foundry, and looking forward to the time when such specifications as Mr. Moldenke has in mind may be adopted, it seems to me desirable to have a more distinctive term. **Mr. Bull.**

Mr. Moldenke. MR. RICHARD MOLDENKE (*Chairman, Committee A-3*).—Mr. Bull is right in this; in fact I have had correspondence with the steel and malleable castings interests along just this line. We have here really a specification for the gray iron foundry only. It would be well if the malleable and the steel castings interests could also tell the furnace men what they require in the way of pig iron. The three branches of the ferrous foundry should be differentiated, and each have their special set of specifications for the pig irons they use.

Mr. Davies. MR. GEORGE C. DAVIES.—Mr. Moldenke is asking us to say that we do not mean what we say. The specifications are written for foundry pig iron. It was always, or at least since 1909, or during discussions prior to the 1909 specifications being adopted, considered as applying to foundry iron including that used in gray iron foundries, malleable iron foundries and steel foundries. That is pointed to, I think, rather clearly and I had no idea this question was coming up here for discussion. In the Appendix, provision is made for phosphorus down as low as a maximum of 0.20 per cent, and as that is the customary specification for malleable castings, it is surely an indication that malleable castings were under consideration at the time the specifications were drawn. There is nothing in the specifications whatever which prevents the steel castings manufacturer specifying his usual requirement of pig iron. In fact the usual requirement in the steel castings trade, as I know it to be, is very much broader in some elements than these specifications permit. It covers him fully on his lower percentage of phosphorus which he may want to require as maximum. There is nothing in those specifications which will limit the man from specifying the lowest procurable phosphorus content as a maximum. I think—it is my personal opinion—that this is applicable to steel and to malleable foundry practice as well as to gray iron practice, and I should be very sorry, on this short notice, to have the question put in such a way as to change the specifications by changing the title; it seems like an amendment negativing the original proposition, and I think it would be well for the proposed specification to proceed in the usual order for acceptance as tentative. If it is wrong, let us find it out. I should like very much to see the Sub-Committee on Pig Iron increased as to size and membership and have this whole measure thoroughly discussed during the ensuing year before the proposed tentative specification is presented for adoption as standard.

Mr. Bull. MR. BULL.—I understand then that the committee does intend this specification to apply to pig iron for steel, malleable iron and gray iron foundries.

Mr. Davies. MR. DAVIES.—I may say that was the understanding of the committee that wrote the specifications of 1909 on which this specification is based, and it is also my personal opinion formed when I was associated with the work of that sub-committee at that time.

Mr. Bull. MR. BULL.—If that is the purpose of the proposed tentative specifications, I want to express my opinion that they are not suitable for foundry pig iron for steel practice. Mr. Moldenke has been informed of several objections that the Committee of the American Foundrymen's Association had to those specifications as applied to the steel foundry, and I do not think it would serve a useful purpose to incorporate steel-making pig irons under the proposed specifications.

Mr. Moldenke. MR. MOLDENKE.—Mr. Davies and I do not agree on this point at all. As a malleable man, I would not be satisfied, for instance, with a variation for silicon 25 points either way. The range is too wide for malleable. There are also objections by the steel men. However, I think Mr. Davies is right in urging the specifications to stand as they are for the present, so that they can be discussed during the year. If the steel and malleable interests bring in their own specifications by next year, we will all know what we are at.

Mr. Wille. MR. H. V. WILLE (*presented in written form by W. Z. Adamson*).—The Baldwin Locomotive Works have purchased their foundry pig iron since 1894 on chemical analysis, specifying the iron and purchasing the same from all parts of the country from Alabama to Pennsylvania. The iron is melted in cupolas, the charges are all figured on the chemical contents of the iron, analysis being made of all the material entering into the cupolas. Tensile and transverse tests and chemical analysis are then made of the resulting heat. These results are tabulated and records used to determine the most satisfactory composition for the various castings.

Two grades of pig iron now are used, the first for convenience sake called cylinder pig which ranges from 1.10 to 1.50 per cent silicon, the second grade known as floor pig iron ranging from 2.50 to 3.00 per cent silicon. By the use of steel and selecting the proper scrap we are able to make castings ranging from 0.80 to 2.50 per cent silicon. Mr. Webster is right, that the A.S.T.M. specifications should cover definite grades of iron and not simply permissible variations, but it should be remembered that pig iron is a raw material and used in combination by the foundryman. I do not think it would be practical for the furnacemen to attempt to guide and assist the foundrymen in making light, medium and heavy castings, as a casting that may come under the heavy castings such as a locomotive cylinder which would necessarily demand a close-grained iron as hard as can be worked,

Mr. Wille. would not have the same composition as a housing coming under the heavy class. Locomotive cylinders also are required to meet different specifications in themselves. Some railroads specify silicon above 1.25 per cent, others a tensile or transverse where it is necessary to have the silicon below 1.25 per cent. The same may be said of accumulator rams which must have exceedingly close metal and would have a very different composition than a base plate or platen. This also is the case of our medium and light castings. The use to which a casting is to be put and the construction of the same should determine its chemical composition. The composition of the scrap which a foundry has on hand or purchases must be taken into consideration by the foundryman. Since nearly as much scrap as pig iron is used, the composition of his scrap has a bearing on the composition of the pig iron which he must use. For these reasons I think it would be folly for the furnaceman to try to make pig iron of the correct analysis to be used in light, medium or heavy castings. It is true that our present A.S.T.M. pig iron specifications are indeed very elastic; as stated by Mr. Webster, "All that they have given the foundryman is a convenient code for writing out a prescription in code words to the blast furnaceman." As there are such a great variety of castings and a great difference in the opinion of the different foundrymen, we need a very elastic specification. In ordering our pig iron we specify the maximum and minimum of silicon, manganese, phosphorus and the maximum of sulfur. There could be hundreds of different grades of pig made from the combinations of the present A.S.T.M. specifications, and the code letters only make additional complications. I do not think that many of the foundries use these specifications or will use them for the reason (as stated by Mr. Webster) "They do not cover any specific foundry product."

The Chairman. THE CHAIRMAN.—I might also state that the Metals Committee of the Federal Specifications Board has before it this question of foundry pig iron, and we have not yet adopted such a specification, but we decided that the A.S.T.M. specifications were, as stated by Mr. Wille, too vague. The practical man in charge of the navy yard or arsenal really wants a specification giving him limitations for his several grades, such that I would say that we would rather endorse the statements that have just been made on that subject.

Mr. Hall. MR. J. H. HALL.—From the point of view of the steel foundryman, when we are told that these specifications are meant to include pig for gray iron and malleable iron and steel, it is a good deal like being told, when it is raining hard, that there is room under one small umbrella for three of us. I am a member of Mr. Bull's A.F.A. Committee, and these specifications were sent to us as steel foundrymen to see how they suited our ideas of specifications to cover steel foundry pig, and I came down to this meeting convinced that these specifications were not intended to cover steel foundry pig at all. When we come to read them through, and look for the places where we can squeeze in under these specifications, we can find a place where we can get in, but it is a close squeeze. Take phosphorus 0.20 per cent, for instance. We fellows making acid steel in the converter want 0.03 and 0.04 per cent. It is the same with the manganese; the manganese, as listed here, with the allowances made, does not suit the steel foundries, does not suit the man running an open-hearth furnace and does not suit the man running a converter. It does seem to me that if these specifications are to cover steel foundry pig and gray iron pig and malleable pig, we steel men can squeeze in, but we are going to get wet all around the corners. **Mr. Hall.**

MR. DAVIES.—May I ask what is a proper analysis requirement for pig iron for steel foundry practice? **Mr. Davies.**

MR. HALL.—When the steel foundryman buys pig for the converter, his phosphorus must be limited to a maximum of 0.04 per cent and his sulfur to 0.04 per cent. The man using the side-blow converter wants as little manganese as possible, as a rule. I am not prepared to speak for the open-hearth men, but I know this specification for manganese does not suit the users of the open-hearth furnace for steel castings. There are open-hearth men here who can answer your question better than I. **Mr. Hall.**

MR. DAVIES.—May I ask as to silicon? **Mr. Davies.**

MR. J. L. UHLER.—As an open-hearth man, I would suggest that if the specifications as written are to be printed in the *Proceedings* to include steel castings, they should be changed. We are large users of standard bessemer pig which has a phosphorus maximum of 0.10 per cent—we do not care how low they go. We also use low phosphorus pig which is bought on the 0.04 per cent, maximum, basis for phosphorus and sulfur. In silicon we desire 2 to 2.5 or 3 per cent; our manganese, not less than 1 or 1.5 per cent. As for carbon, we ask that the total be around 4 per cent. **Mr. Uhler.**

MR. DAVIES.—The specification which Mr. Uhler gives for open-hearth practice is silicon, 2.00 to 2.50 or 3.00 per cent; phosphorus, 0.04 per cent, maximum; sulfur, 0.04 per cent, maximum; manganese, 1.00 to 1.50 per cent. The specifications read: "The pig iron shall conform to the chemical specifications as specified by the purchaser at the time of purchase, with the following permissible variations: Silicon 0.25 per cent, above and below." That covers the narrowest **Mr. Davies.**

Mr. Davies. specification which the gentleman makes for silicon. He says he wants 2.00 to 2.50 per cent; there it is covered by the specifications. He says concerning that variation, instead of 0.25 per cent either way, he may be willing to make it 0.50 per cent either way. Certainly the specifications should not be criticized for making narrower lines. He says he wants phosphorus 0.04 per cent, maximum; sulfur 0.04 per cent, maximum. Section 2 (*b*) states that "the percentages specified for phosphorus and manganese may be used as minimum or maximum figures . . ." It thus provides for the maximum percentage. Sulfur is to be "not over specified percentage." It covers him on three elements there. He says he wants manganese 1.00 to 1.50 per cent. The specifications provide for 0.20 per cent variation either way. He may specify 1.20 per cent and get 1.00 to 1.40 per cent. There is a very slight difference between what he wants and what he gets under the specifications.

Mr. Bull. MR. BULL.—Mr. Moldenke does not believe in the position taken by Mr. Davies. We steel foundrymen occupy the position of consumer in the consideration of this question. Now there is one man on the committee representing steel foundrymen. It does not seem fair to me for the steel foundryman to have limitations imposed upon him which he does not enjoy and for the preparation of which he has not had suitable representation.

Mr. Moldenke. MR. MOLDENKE.—It comes down finally to what I have said before, that either the steel and the malleable men must make their own specifications, or perhaps the Sub-Committee on Pig Iron can enlarge to include both interests.

You will find that most foundries, even the Baldwin Locomotive Works, are using the specifications unconsciously. Even when they ask for 2.25 to 2.75 per cent of silicon, they are certain to analyze the iron they get to know the actual content, to figure out their mixtures. It is much better to ask for 2 per cent of silicon direct, even if expecting to get 1.75 to 2.25 than to let the furnaceman guess at what the foundryman really wants. The pig iron man likes to know what the foundryman wants, because then he can send from his stock what he is asked for. It is always better to specify just what is wanted. Then you will get as nearly this as the furnaceman can ship. Otherwise, you may get a variety of compositions, each, none the less, falling within the range of variation allowed. It makes for uncertain foundry results, even if it gives the furnaceman an opportunity to clean up his yard.

Mr. Adamson. MR. W. Z. ADAMSON.—How does the smaller foundryman usually order? He receives a list from the furnaceman stating "We have a hundred tons of iron of the following analysis and two hundred of this

Mr. Adamson. analysis," and the foundryman selects the pig he desires. This is the method usually pursued.

Mr. Moldenke. MR. MOLDENKE.—Mr. Webster wants the foundryman educated in regard to the irons he should ask for.

Mr. Adamson. MR. ADAMSON.—You know the foundrymen better than anybody, and they know more about the foundry business than the furnacemen. What I take exception to is the statement that the furnacemen should make pig iron for light, medium or heavy castings; you made up a list of these very things, and they all vary in silicon contents.

Mr. Moldenke. MR. MOLDENKE.—I object to that myself. I do not agree with the thought of Mr. Webster, even when presenting his paper by request. I think that foundrymen should know enough about their business to be able to specify just what they want. The specifications allow for liberal ranges of variation and hence can accommodate quite a variety of specifications easily. Hence they are not burdensome, and yet cover the cast iron foundry situation with sufficient precision to answer every purpose.

Mr. Wood. MR. WALTER WOOD.—There has been some suggestion of "grading" in connection with pig iron. I thought that term belonged to our grandfathers. When I buy pig iron, which is in very large amounts, running into thousands of tons, what I want the furnaceman to do is to bring me his lists of iron for sale showing so much silicon, sulfur, phosphorus and manganese. Then I tell him what I will accept and I want him to deliver the metal within specified variations. I know a furnace cannot make uniform iron, not even for twelve hours; the furnaceman would like to, but he cannot. What I want him to bring (and what he only can bring) is what he has made, and tell me what it is, and I will take what I can use, and I want it delivered to me within reasonable limitations. Speaking only for the gray iron foundryman (not for the malleable and steel men) the specifications that have been presented by the pig iron committee are as practical and accurate and cover, as nearly as I can see, the practical needs of the foundryman. I shall be very sorry to see us go back to the term designation by grades, because it is too indefinite. Mr. Webster himself speaks only of grading iron by its silicon and sulfur content; yet a foundryman wants to know the phosphorus and manganese content. To undertake to have grading of iron that will cover all variations of phosphorus and manganese would be almost hopeless. I speak as I have said, from the gray iron man's standpoint. Let us hold to that which will keep everything clear and definite; let the furnaceman make the best iron he can under his circumstances; let him come to the trade and say "That is

Mr. Wood. what I have made; what will you give me for it?" And the buyer will choose that which he can best use. Let him choose material fitted for his own use; let him know his business so that he appreciates what he wants, and arrange the analysis lists so he can buy it accordingly. If Mr. Davies would like to have the malleable people, or the steel people, have specifications that will cover fully their wants as to percentage of the metalloids, let it be so enlarged and so framed as to state their needs but do not tie the buying and selling of iron down to the old fashioned methods that were used when I went into business over fifty years ago, namely, grading that does not let you know fully what the metal is, but adopt methods which will tell you the full contents of the metal offered.

Mr. Buck. MR. W. E. BUCK.—From the viewpoint of the ingot producer whose product is used in making sheet metal and plates, the requirement on manganese would be especially bad for us if we have to accept a 20 point variation either way. We do not desire that at all.

Another point, it is merely a detail: Low-silicon, rather high-sulfur pig, meeting the higher sulfur requirements on basic machine-cast pig is a very difficult thing to sample by drilling. Any of you gentlemen who have had experience in that line know the almost impossibility of trying to drill such a pig, that is, one with about 0.05 per cent of sulfur, with perhaps 0.40 per cent of silicon.

Mr. Moldenke. MR. MOLDENKE.—The case you cite is a very special one and is not covered in the specifications. However, you can readily make a change in the text when ordering, by simply stating that the manganese you ask for shall be maximum. That will remove the 0.20 per cent variation either way.

Where hard irons are used, and drilling cannot be resorted to in collecting the sample for analysis, chips are broken off and pulverized in a steel mortar. Where the iron poured into castings becomes white or hard, a little of it is "shotted" by pouring into water, and these pellets, or shot, are used for the sample by pounding fine in the steel mortar.

Mr. Buck. MR. BUCK.—There is this difficulty, if we write into a specification that the manganese shall be maximum, the blast furnace will charge a penalty for the manganese maximum.

Mr. Moldenke. MR. MOLDENKE.—That is true. Particularly in the South, the irons of which are notoriously low in manganese. But to get high manganese they have to pay fancy ore prices, and necessarily they will charge accordingly.

[The motion to accept the proposed Tentative Specifications for Foundry Pig Iron for publication as tentative was approved by a vote of 25 affirmative and 8 negative.—ED.]

Mr. Webster.

MR. WILLIAM R. WEBSTER (*Author's Closure, by letter*).—We are all greatly indebted to Mr. Moldenke for his complete, up-to-date review and summary of my former "Note on a Scheme for the Study of the Physics of Cast Iron." He has now put this matter in very complete form for convenient reference and covered the advances that have been made in this work since 1895. His conclusions are as follows; they are very brief and to the point, but they cover much ground and can be endorsed by all of us:

> "A discussion of every point included in the above scheme of study would assume the bulkiness of a book, and hence no attempt will be made in that direction. The summary of a life's work in the production of good castings—necessarily interwoven with the chemical and physical characteristics of cast iron—is as follows:
>
> 1. Use the best materials suited to the production of the castings wanted·
> 2. Employ correct melting, molding and finishing process.
> 3. Gate the molds correctly, so that the good materials, properly manipulated, may be given the best chance possible to produce good work."

The presentation of the paper in connection with the Proposed Tentative Specifications for Foundry Pig Iron for discussion was an excellent plan, as by this course a much better discussion was brought out than could have been secured in any other way. The enlargement of the Sub-Committee on Pig Iron is one of the good results that it has already brought about.

On reading over the discussion it is evident that the suggestions in my paper were in some cases misunderstood and the whole matter was treated as though something new had been brought up for consideration by the committee and others. Now, as a matter of fact, this is not the case, as is shown by the following quotation from my former paper of 1895 referred to above, which practically covers the same ground and in the same manner:

> "I am fully convinced that the relations between the chemical constitution and physical character of cast iron are much closer than is generally admitted to-day. If proof of this is wanted, we have it in the success of those who have given up the old rule-of-thumb methods in running their foundries. There is no doubt that, in a full discussion and investigation of this kind, new data will be brought to light which, in connection with the results of the valuable researches already made, would enable us to make tables, and lay down rules for the founder's guidance, that would be of the greatest value to the makers and users of cast iron. In other words, from a cupola or furnace mixture, of known chemical composition, we could predict with certainty the physical properties of castings of any given size or shape (due allowance being made for change of composition in melting). Or, when certain physical properties were required in a casting of given size and shape, the chemical composition of the different mixtures that would produce these results could at once be given with-

Mr Webster. out any of the 'cutting and trying' that we now have. This is not too much to expect; and it is not too much to hope that each will do his part in bringing about a result so beneficial to all."

My views are the same now as when the above was written in 1895, only very much stronger, as everything then claimed by the writer has been confirmed over and over again since that time. All that is now asked is that the foundrymen themselves standardize those of their methods that have been shown to give the best results in practice.

The first A.S.T.M. specifications for Foundry Pig Iron were not adopted until 1904, about nine years later than the first discussion on the Physics of Cast Iron.

Mr. Moldenke has fully covered in a most satisfactory way the present conditions of the pig iron situation and suggests means of improving on same by bringing all of the producers and consumers together on the same general lines that have given such good results as those followed on our steel specifications. By this course he hopes to and will undoubtedly remove many of the hair-splitting requirements now called for in the use of the present specifications and secure a much larger tonnage on a reduced number of standard grades of pig iron.

I have never advocated that the blast furnace men should furnish different grades of pig iron that would be of the correct analysis to be used in light, medium or heavy castings, as I have always fully recognized the important part the scrap used plays in foundry practice and the changes of chemical composition that has to be allowed for in melting. My suggestion was merely to bring into more general use the good practice that has been tried out in different branches of this work and found to give satisfactory results, on similar lines as those referred to by Mr. Wille as being used at The Baldwin Locomotive Works, where he shows that they have been purchasing their foundry pig iron on chemical analysis since 1894 with satisfactory results, and that they now only use two grades of pig iron.

If Mr. Wille will give us the chemical compositions of the different grades of castings they make he will add very much to the value of his remarks. It would also confirm my views as given above by first showing the chemical composition that is required in each case, to give the desired physical results in the finished casting and, second, to show how they work up to them by the use of pig iron of known chemical composition and scrap after making due allowances for loss in melting. By doing this he would give us a comparatively complete story of how their everyday work is carried on.

Mr. Webster.

Others are doing the same thing in their different lines of work and it is just such information that we need for discussion and use either in our specifications, or in some other satisfactory manner to the committee that will bring this much desired information before our members and allow them to use our present specifications more intelligently than they have been doing.

In this connection, I desire to quote here the views expressed by the chairman, Mr. Burgess, showing the difficulties that are encountered in trying to make practical use of our present specifications:

> "I might also state that the Metals Committee of the Federal Specifications Board has before it this question of foundry pig iron, and we have not yet adopted such a specification, but we decided that the A.S.T.M. specifications were, as stated by Mr. Wille, too vague. The practical man in charge of the navy yard or arsenal really wants a specification giving him limitations for his several grades, such that I would say that we would rather endorse the statements that have just been made on that subject."

I am greatly obliged to Mr. Burgess for bringing this matter before us as it clearly shows others agree with me in that our committee has been working along the wrong lines on our pig iron specifications and have not as yet given us any suggestions as to how to make the best practical use of their specifications. The problem now before the Metals Committee of the Federal Specifications Board should be taken up at once by our Committee A-3 and the necessary information procured that would enable the proper use to be made of our specifications, or at least showing what other foundries, making the same class of castings, consider the proper chemical composition to use in their finished castings, as well as the pig irons they used in connection with scrap to get the desired results in their finished work. Information of this kind is of such great importance that it would be well for the committee to consider forming a sub-committee to get such information on the most important classes of castings that are now in general use, as others will certainly be calling for information of this kind from time to time to assist them in their general foundry practice.

Enough has been brought out through the papers and discussions to show the time is ripe for a general discussion on the physics of cast iron, so that our committee may have the views of experts and others who have been working on these matters for years. They have accumulated much valuable information that we sorely need at this time. All of this information should be available if the proper course is taken to secure it. I would, therefore, suggest that the present paper, with the tentative specifications and discussion, be presented to

Mr. Webster. the Iron and Steel Committee of the American Institute of Mining and Metallurgical Engineers with a request from Committee A-3 that this matter be brought up for general discussion at the Institute's meeting next February in New York City. If this course is pursued, we will get a much better discussion from the blast furnace men, foundrymen, and others than we could expect at any of our own meetings.

In a discussion of this kind, it might be well to concentrate as much as possible on the chemical composition of the finished castings of different grades that has been shown to give the best results in practice and from that to work backward to the pig irons used in connection with ordinary amounts of scrap and general losses in chemical composition due to melting. A full discussion on these subjects would be very valuable to our members, as much general information would be brought out that it would be almost impossible to secure in any other way.

I take pleasure in giving another abstract from my 1895 paper as it formerly assisted in bringing out very good discussions before the Institute on the Physics of Cast Iron and it is to be hoped it will be of like assistance at this time:

> "Several works have employed chemists, and struggled with these problems for years, but each one carefully guards the results; and at the present time many seem disinclined to add theirs to the common store. But, if they could be induced to make their methods and results public, by freely discussing them before this Institute, they would be well repaid by the assistance they would receive through such an interchange. Nobody is as wise as everybody; and nobody loses, as a general rule, by a generous frankness which secures the criticism and help of others. The possible loss through giving to competitors a few shop secrets is really trivial in comparison."

REPORT OF COMMITTEE A-4

ON

HEAT TREATMENT OF IRON AND STEEL.

Committee A-4 has held four meetings during the past year as follows: At Asbury Park on June 23, 1921; at New York on October 14, 1921; at New York on February 21, 1922; at Cleveland on March 31, 1922.

The following new members were elected during the year:

R. S. MacPherran, Allis Chalmers Manufacturing Co., Milwaukee, Wis.;
G. A. Reinhardt, Youngstown Sheet and Tube Co., Youngstown, Ohio;
H. W. Gilbert, National Malleable Castings Co., Cleveland, Ohio;
F. P. Gilligan, Pres. A.S.S.T., 11 Laurel St., Hartford, Conn;
T. D. Lynch, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.;
H. E. Smith, New York Central Lines, Room 1520, Grand Central Terminal, New York City;
James Neale, Brown and Co., Inc., Wayne Iron and Steel Works, Pittsburgh, Pa.;
A. V. DeForest, American Chain Co., Bridgeport, Conn.

The following resignations were accepted with regret:

Guilliaem Aertsen;
Bradley Stoughton.

Sub-Committee V on Heat Treatment of Wrought Iron is making an investigation to determine the desirability of annealing iron chain at intervals. Some fifty specimens have been collected.

Sub-Committee II on Heat Treatment of Steel Castings has recommended a substitute, appended hereto, for the present Recommended Practice for Annealing of Carbon-Steel Castings.

Sub-Committee I on Heat Treatment of Rolled and Forged Carbon Steel is considering the adoption of charts similar to the S.A.E. Heat Treatment charts which Sub-Committee III has adopted.

Sub-Committee III on Heat Treatment of Alloy Steels is searching the existing specifications of the Society with a view to the consideration of any changes in specifications involving heat treatment.

The committee recommends that the proposed Recommended Practice for Heat Treatment of Carbon-Steel Castings prepared by Sub-Committee II and appended hereto[1] be accepted for publication as tentative to replace, when adopted, the present Recommended Practice for Annealing of Carbon-Steel Castings (A 36 – 14).

This report has been submitted to letter ballot of the committee, which consists of 29 members, of whom 20 have voted affirmatively, none negatively, and 9 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. M. BOYLSTON,
Chairman.

J. H. HALL,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Recommended Practice for Annealing of Carbon-Steel Castings referred to in this report were accepted for publication as new Tentative Recommended Practice for Heat Treatment of Carbon-Steel Castings and appear on page 643.

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[1] See p. 643.—ED.

REPORT OF COMMITTEE A-5

ON

CORROSION OF IRON AND STEEL.

The report of Committee A-5 consists of the reports of Sub-Committee II on Preservative Metallic Coatings for Metals, Sub-Committee III on Inspection of the Fort Sheridan, Pittsburgh, and Annapolis Tests and Sub-Committee V on Total Immersion Tests.

Sub-Committee II reports considerable progress in the development of a program for atmospheric exposure tests of galvanized sheets, the aim of the work being to correlate the results of service with those obtained in the various types of laboratory tests, such knowledge being almost entirely lacking at the present time. The locations for the atmospheric exposure tests will probably be Pittsburgh, Pa., and Depew, Ill., the latter being in the neighborhood of a smelter works, which locations should prove sufficiently severe as will give results within a reasonable interval of years.

The work of Sub-Committee III continues to furnish valuable information, the results at the Fort Sheridan location showing three entire groups of sheets completely failed, with an additional group of 14 sheets all failed excepting one sheet. These failures are entirely confined to the non-copper-bearing light gage sheets, the same groups of sheets being among the first failures at the Pittsburgh location. The light gage sheets at the Pittsburgh location, with the notable exceptions of the copper-bearing Bessemer steel with no failures, and the copper-bearing acid open-hearth steel with only four failures, have completed their history, and, as might be anticipated, the heavier gage sheets are failing in substantially the same order as the light sheets, 70 per cent of the non-copper-bearing sheets showing failure at the end of 64 months' exposure, while no failures have occurred in the copper-bearing sheets at this time.

No failures have occurred at the Annapolis, Md., location.

Sub-Committee V, which is conducting the total immersion tests, reports no additional failures during the past year; however, the last inspections indicated that many of the remaining test specimens were showing considerable attack and further failures might be expected at early subsequent inspections.

One sad event has marked the committee record for the past year, this being the death of the chairman, Mr. Voorhees, who passed away in September, following some months of ill health. It has been the good fortune of the committee to have worked under his leadership for seven years. During this time the exposure tests of ferrous sheets have been planned, erected and some of them have completed their history. His wisdom, his calm, impartial and far-sighted judgment have been of the utmost help. Yet after the details of technical work have become distant history, we will remember Voorhees, the man, his wide field of interest, his kindly sympathy, his generous helpfulness, and his genial and lovable personality.

This report has been submitted to letter ballot of the committee which consists of 42 members, of whom 31 have voted affirmatively, none negatively, and 11 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. H. GIBBONEY,
Acting Chairman.

J. A. AUPPERLE,
Secretary.

REPORT OF SUB-COMMITTEE II ON PRESERVATIVE METALLIC COATINGS FOR METALS.

On account of the change in organization of the sub-committee during the past year, but little was accomplished in actual work. Upon the resignation of Dr. G. K. Burgess as chairman, Mr. H. S. Rawdon was appointed chairman *pro tem.* until the election of the chairman for the main committee.

One meeting was held during the year at which was drawn up, subject to the approval of Committee A-5, a program for a series of atmospheric exposure tests of galvanized sheets. The immediate object of the proposed tests is to show in terms of service life the value and meaning of the results of the laboratory tests commonly used for the testing of galvanized products. Such a series of tests should be of very considerable help in drawing up suitable specifications for galvanized products.

Respectfully submitted on behalf of the sub-committee,

H. S. Rawdon,
Chairman pro tem.

REPORT OF SUB-COMMITTEE III ON INSPECTION OF THE FORT SHERIDAN, PITTSBURGH, AND ANNAPOLIS TESTS.

Sub-Committee III on Inspection has held three meetings during the past year.

FIRST MEETING.

The first meeting was held at Fort Sheridan, Ill., on October 17, 1921, with Messrs. Aupperle, Buck, Fleming, McDonnell and Smith present; Messrs. Cooper, Gibboney, and the representatives of the Bureau of Steam Engineering of the U. S. Navy Department, and the Quartermaster's Corps of the U. S. War Department, being absent.

The Fort Sheridan sheets were inspected on October 17, 1921, followed by the inspection of the Pittsburgh sheets on October 18, 1921, and the Annapolis sheets on October 19, 1921. Mr. Gibboney joined the sub-committee at Pittsburgh, the representative of the Bureau of Steam Engineering of the U. S. Navy Department joined the sub-committee at Annapolis, and Mr. Smith left the sub-committee at Pittsburgh, not making the Annapolis inspection. Members filing data sheets for these inspections are as follows:

Fort Sheridan.—Messrs. Aupperle, Buck, Fleming, McDonnell and Smith.

Pittsburgh.—Messrs. Aupperle, Buck, Fleming, Gibboney, McDonnell and Smith.

Annapolis.—Messrs. Aupperle, Buck, Fleming, Gibboney, McAdam and McDonnell.

The results of these inspections in composite form have been filed in the office of the Society. Copies may be obtained upon application to the Secretary-Treasurer.

The following photographs of the Fort Sheridan sheets showing failures taking place at this location, were made on October 17, 1921, representing an exposure period of 54 months.

Fig. 1 represents the condition of sheet O 20 (No. 22 Gage Low-Copper Open-hearth Steel, Series A), having failed due to hole in lower end.

Figs. 2, 3 and 4 represent the condition of sheets S 16, S 22 and S 25 and 26 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co. These sheets have failed due to holes in lower ends.

Sheet AA13 (No. 16 Gage Bessemer Steel, Series A) has failed due to holes in lower end. Through oversight this sheet was not photographed. Sheet S 28 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co., has failed due to holes in lower end. Through oversight this sheet was not photographed.

Fig. 5 represents the condition of sheet Z 420 (No. 22 Gage Low-Copper Open-hearth Steel, Series B), manufactured by the Youngstown Sheet and Tube Co. This sheet failed due to holes in lower end.

The following photographs of the Pittsburgh sheets showing failures taking place at this location, were made on October 18, 1921, representing an exposure period of 58 months:

Fig. 6 represents the general view for the Pittsburgh sheets as appearing on the rack at this inspection.

Fig. 7 represents the condition of sheets B 19 and 20 (No. 22 Gage Open-hearth Steel, Series A), failed due to holes in lower ends.

Fig. 8 represents the condition of sheets H 45 and 47, (No. 22 Gage Copper-Bearing Basic Open-hearth Steel, Series A), sheet H 47 having failed due to hole in lower end. Sheet H 45 was reported as failed at the April 5, 1921, inspection.

Figs. 9 and 10 represent the condition of sheets K 35 and 36, 40 and 41 (No. 22 Gage Copper-Bearing Acid Open-hearth Steel, Series A). Sheets K 36 and 41 have failed due to holes in lower ends. Sheets K 35 and 40 have not failed.

Fig. 11 represents the condition of sheets M 31 and 32 (No. 22 Gage Open-hearth Steel, Series B), manufactured by the Alan Wood Iron and Steel Co., sheet M 31 having failed due to holes in lower end. Sheet M 32 was reported as failed at the May 11, 1920, inspection.

Figs. 12, 13 and 14 represent the condition of sheets Z 509 and 513, 516 and 607, 608 and 609 (No. 22 Gage Copper-Bearing Open-hearth Steel, Series B), manufactured by the Youngstown Sheet and Tube Co. These sheets have failed due to holes in lower ends.

Fig. 15 represents the condition of sheets BB 22 and 23 (No. 16 Gage Open-hearth Steel, Series A), sheet BB 23 having failed due to holes in lower end. Sheet BB 22 has not failed.

Figs. 16 to 19, inclusive, represent the condition of sheets DD 29 and 30, 31, 54 and 55, and 57 and 58 (No. 16 Gage Low-Copper Pure Iron, Series A). These sheets have failed due to holes and ragged edges at lower ends.

Figs. 20, 21 and 22 represent the condition of sheets MM 35 and 36, 38 and 39, 40 and 41, (No. 16 Gage Open-hearth Steel, Series B), manufactured by the Alan Wood Iron and Steel Co., sheets MM 35, 38 and 40 having failed due to holes in lower ends. Sheets MM 36, 39 and 41 have not failed.

Figs. 23 to 26, inclusive, represent the condition of sheets OO 29 and 30, 31, 34 and 35, and 36 (No. 16 Gage Low-Copper Open-heart Steel, Series A), having failed due to one or more holes in the lowe ends.

Figs. 27 and 28 represent the condition of sheets XX 36 and 37, 41 and 42 (No. 16 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co., sheets XX 37 and 42 having failed due to holes and ragged edges at the lower ends. Sheet XX 41 was reported as failed at the May 11, 1920, inspection, and sheet XX 36 was reported as failed at the October 12, 1920, inspection.

Fig. 29 represents the condition of sheet YY 8 (No. 16 Gage Low-Copper Wrought Iron, Series B), manufactured by the Youngstown Sheet and Tube Co., having failed due to hole at the lower end.

Sheet CC 18 (No. 16 Gage Copper-Bearing Pure Iron, Series A), and sheets DD 27 and 28 (No. 16 Gage Low-Copper Pure Iron, Series A), are reported as failed due to holes in lower ends. No photographic records were made of these sheets at this inspection, due to inability because of location to place the photographic tower between the sheets and the wall of an adjacent building.

Fig. 31 shows the general view for the Annapolis sheets as appearing on the rack at the October 19, 1921, inspection. The rate of corrosion for the test sheets exposed at Annapolis continues slow, and no failures have occurred at this location after an exposure period of 60 months.

SECOND MEETING.

The second meeting was held at Fort Sheridan, Ill., on April 10, 1922, with Messrs. Aupperle, Buck, Cooper, McDonnell and Smith present; Messrs. Fleming, Gibboney and the representatives of the Bureau of Steam Engineering of the U. S. Navy Department, and the Quartermaster's Corps of the U. S. War Department being absent.

The Fort Sheridan sheets were inspected on April 10, 1922, followed by a partial inspection of the Pittsburgh sheets on April 11, 1922, Mr. Gibboney joining the sub-committee at Pittsburgh. On account of rain at Pittsburgh it was found impractical to make a detail inspection of these sheets for surface texture, color and adherence of the rust, the observations being limited to sheets showing failure since the last inspection.

The following members filed data sheets covering the Fort Sheridan inspection:

Messrs. Aupperle, Buck, Cooper, McDonnell and Smith.

The results of the Fort Sheridan inspection in composite form have been filed in the office of the Society. Copies may be obtained upon application to the Secretary-Treasurer.

The following photographs of the Fort Sheridan sheets showing failures taking place at this location were made on April 10, 1922:

Fig. 30 represents the condition of sheet AA 13 (No. 16 Gage Bessemer Steel, Series A). This sheet failed due to holes in lower end prior to the October 17, 1921, inspection, representing an exposure period of 60 months.

Fig. 32 represents the condition of sheets S 18 to 28, inclusive, in a group consisting of sheets S 15 to 28 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co. Sheets S 17, 18, 19, 20, 21, 23, 24 and 27 have failed, due to holes in lower ends. Sheets S 16, 22, 25, 26, and 28 were reported as failures at the October 17, 1921, inspection. Sheet S 15 has not failed.

Fig. 33 represents the condition of sheet X 23 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co. This sheet shows a laminated zone about half way up on the right edge, which is a defect in manufacture not sufficient to classify the sheet as a failure at this time.

The following photographs of the Pittsburgh sheets showing failures taking place at this location were made on April 11, 1922, representing an exposure period of 64 months.

Fig. 34 represents the condition of sheet H 43 (No. 22 Gage Copper-Bearing Basic Open-hearth Steel, Series A), this sheet having failed due to hole in the lower end.

Figs. 35 and 36 represent the condition of sheets K 37 and 39 (No. 22 Gage Copper-Bearing Acid Open-hearth Steel, Series A), having failed due to holes in the lower ends.

Figs 37 and 38 represent the condition of sheets Z 214 and 714 (No. 22 Gage Open-hearth Steel, Varying Copper Content, Series B), manufactured by the Youngstown Sheet and Tube Co. These sheets have failed due to holes in the lower ends.

Fig. 39 represents the condition of sheets BB 20 and 21 (No. 16 Gage Open-hearth Steel, Series A), having failed due to holes in the lower ends.

Figs. 40 and 41 represent the condition of sheets CC 15 and 17 (No. 16 Gage Copper-Bearing Pure Iron, Series A). Sheet CC 15 failed due to a single hole in the lower end. Sheet CC 17 shows a laminated area near the lower end which has rusted through in a hole, causing failure of this sheet.

Figs. 42 and 43 represent the condition of sheets DD 8 and 9,

TABLE I.—FORT SHERIDAN TESTS. INSPECTION OF OCTOBER 17, 1921.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
II	4.094	S	D	T
ZZ (HC)	3.982	S	D	T
KK	3.970	S	D	T
BB	3.294	M	D	T
EE	3.250	M	D	T
TT	3.243	M	D	L
MM	3.200	M	D	L
HH	3.186	M	M	T
VV	2.726	M	M	T
UU	2.646	M	M	T
ZZ (LC)	2.600	C	M	L
OO	2.350	C	M	L
CCC	2.200	C	ML	L
DD	2.095	C	L	L
CC	2.000	C	L	L
XX	1.843	C	L	L
YY	1.800	VC	M	L
SS	1.650	VC	L	L
AA	1.533	VC	L	L
No. 22 Gage.				
I	4.305	VS	D	T
K	4.087	S	D	T
Z (HC)	3.883	S	D	T
H	3.490	S	M	T
M	3.185	M	D	T
T	3.157	M	D	T
E	3.150	M	D	T
B	3.015	M	M	T
V	2.959	M	M	T
U	2.659	M	M	T
Y	2.400	C	M	L
C	2.200	C	L	L
D	2.100	C	L	L
X	2.000	C	L	L
A	1.800	VC	L	L
S	1.800	VC	L	L

NOTE.—ZZ (HC) indicates copper 0.154 to 0.658 per cent.
ZZ (LC) indicates copper 0.031 per cent or under.
Z (HC) indicates copper 0.126 to 0.554 per cent.
Z (LC) indicates copper 0.020 per cent or under.

All of the O and Z (LC) sheets exposed at Fort Sheridan are recorded as failures in this report, therefore no rating appears in this table.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

and 49 (No. 16 Gage Low Copper Pure Iron, Series A) having failed due to holes in the lower ends.

Fig. 44 represents the condition of sheet MM 41 (No. 16 Gage Open-hearth Steel, Series B), manufactured by the Alan Wood Iron and Steel Co. This sheet has failed due to holes and ragged edge at the lower end.

TABLE II.—PITTSBURGH TESTS. INSPECTION OF OCTOBER 18, 1921.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
II	4.750	VS	..	T
ZZ (HC)	4.466	VS	..	T
KK	4.439	VS	...	T
EE	4.083	S	..	T
HH	3.833	S	..	T
TT	3.595	S	..	T
UU	3.405	S	..	T
VV	3.320	M	..	T
BB	2.990	M	..	T
CCC	2.944	M	..	L
MM	2.380	C	..	L
CC	2.278	C	..	L
OO	1.562	VC	..	L
DD	1.531	VC	..	L
No. 22 Gage.				
I	4.888	VS	..	T
Z (HC)	4.400	VS	..	T
K	4.333	VS	..	T

NOTE.—ZZ (HC) indicates copper 0.153 to 0.586 per cent.
Z (HC) indicates copper 0.128 to 0.712 per cent.

In the case of the A, C, D, E, O, S, T, U, V, X, Y, Z (LC), AA, SS, and ZZ (LC), recorded as complete failures in the 1919, 1920 and 1921 reports, no further detail record appears. All of the B, M and YY, and a majority of the H and XX sheets exposed at Pittsburgh, Pa., are recorded as failures in this report, therefore no rating appears in this table.

The above table has been compiled from the composite report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

Figs. 45 and 46 represent groups of copper-bearing and non-copper-bearing Bessemer steel sheets as now appearing on the Pitts-

TABLE III.—ANNAPOLIS TESTS. INSPECTION OF OCTOBER 19, 1921.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
II	4.416	VS	D	T
KK	3.898	S	D	T
ZZ (HC)	3.880	S	D	T
TT	3.595	S	D	T
EE	3.542	S	M	T
HH	3.406	S	M	T
BB	3.314	M	D	T
MM	2.976	M	M	T
UU	2.869	M	M	T
ZZ (LC)	2.750	M	M	L
VV	2.702	M	M	T
DD	2.570	C	L	L
OO	2.291	C	M	L
CC	2.166	C	L	L
CCC	2.125	C	L	L
XX	2.035	C	L	L
YY	1.666	VC	L	L
AA	1.639	VC	L	L
SS	1.535	VC	L	L
No. 22 Gage.				
I	4.364	VS	D	T
K	4.135	S	D	T
Z (HC)	4.111	S	D	T
E	3.545	S	D	T
H	3.468	S	M	T
T	3.428	S	D	T
B	3.083	M	M	T
M	2.940	M	M	T
V	2.774	M	M	L
U	2.738	M	M	L
C	2.583	C	L	L
Z (LC)	2.416	C	M	L
A	2.400	C	ML	L
D	2.095	C	L	L
O	2.011	C	M	L
Y	2.000	C	M	L
X	1.839	C	L	L
S	1.739	VC	L	L

NOTE.—ZZ (HC) indicates copper 0.162 to 0.662 per cent.
ZZ (LC) indicates copper 0.034 per cent or under.
Z (HC) indicates copper 0.138 to 0.654 per cent.
Z (LC) indicates copper 0.0.0 per cent or under.

The above table has been compiled from the composite inspection report by averaging the reports on texture on h sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols the table represent the majority opinions of the inspectors.

TABLE IV.—FORT SHERIDAN TESTS. INSPECTION OF APRIL 10, 1922.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
II	4.874	VS	D	T
KK	4.768	VS	D	T
ZZ (HC)	4.400	VS	D	T
HH	3.859	S	D	T
BB	3.729	S	D	T
EE	3.617	S	M	T
MM	3.409	S	D	T
TT	3.286	M	D	T
VV	3.200	M	M	T
UU	3.154	M	M	T
OO	2.800	M	M	T
CCC	2.450	C	ML	L
ZZ (LC)	2.400	C	L	L
XX	2.200	C	L	L
YY	2.067	C	M	L
CC	2.017	C	L	L
DD	2.012	C	L	L
AA	1.953	C	L	L
SS	1.850	C	L	L
No. 22 Gage.				
I	4.968	VS	D	T
K	4.562	VS	D	T
Z (HC)	4.067	S	D	T
H	3.945	S	D	T
M	3.828	S	D	T
E	3.550	S	M	T
T	3.443	S	D	T
B	3.046	M	M	T
U	2.957	M	M	T
V	2.957	M	M	T
Y	2.500	C	M	TL
C	2.400	C	M	L
D	1.900	C	L	L
X	1.554	VC	L	L
A	1.400	VC	L	L
S	1.088	VC	L	L

NOTE.—ZZ (HC) indicates copper 0.154 to 0.658 per cent.
ZZ (LC) indicates copper 0.031 per cent or under.
Z (HC) indicates copper 0.126 to 0.554 per cent.
Z (LC) indicates copper 0.020 per cent or under.

All of the O and Z (LC) sheets exposed at Fort Sheridan are recorded as failures in this report, therefore no rating appears in this table.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE V.—AVERAGE SURFACE TEXTURE, FORT SHERIDAN TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, AND APRIL, 1922. SHEETS EXPOSED APRIL 9, 1917.

Group.	Type Designation.	Date of Inspection															
		Oct. 8, 1917.		April 8, 1918.		Mar. 31, 1919.		May 10, 1920.		Oct. 11, 1920.		April 4, 1921.		Oct. 17, 1921.		April 10, 1922.	
		Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
	No. 16 GAGE.																
BB	Open-hearth Steel, Series A	3.765	S	3.721	S	3.252	M	3.470	M	3.608	S	3.635	S	3.29	M	3.729	S
II	Copper-Bearing Bessemer Steel, Series A	3.763	S	4.089	S	3.977	S	3.934	S	4.008	S	4.632	VS	4.094	S	4.874	VS
KK	Copper-Bearing Acid Open-hearth Steel, Series A	3.750	S	4.006	S	4.098	S	4.085	S	4.254	VS	4.452	VS	3.970	S	4.768	VS
HH	Copper-Bearing Basic Open-hearth Steel, Series A	3.500	S	3.875	S	3.756	S	3.625	S	3.529	S	3.800	S	3.186	M	3.859	S
DD	Low-Copper Pure Iron, Series A	3.369	M	3.053	M	2.782	M	2.474	C	1.947	C	2.295	C	2.095	C	2.012	C
UU	Copper-Bearing Pure Iron, Series B, Allegheny Steel Co	3.346	M	3.307	M	3.286	M	3.279	M	3.167	M	3.200	M	2.646	M	3.154	M
ZZ(HC)	Copper-Bearing Steel, Series B, Youngstown Sheet and Tube Co	3.341	M	4.011	S	4.156	S	4.023	S	4.422	VS	4.055	S	3.982	S	4.400	VS
VV	Copper-Bearing Pure Iron, Series B, Whitaker-Glessner Co	3.217	M	3.316	M	3.286	M	3.099	M	3.000	M	3.032	M	2.726	M	3.200	M
TT	Copper-Bearing Steel, Series B, Newport Rolling Mill Co	3.187	M	3.205	M	3.571	S	3.580	S	3.405	S	3.600	S	3.243	M	3.286	M
EE	Puddled Iron, Series A	3.156	M	3.594	S	3.357	M	3.281	M	3.583	S	3.800	S	3.250	M	3.617	S
CC	Copper-Bearing Pure Iron, Series A	3.031	M	2.906	M	2.583	C	2.635	M	1.931	C	2.150	C	2.000	C	2.017	C
XX	Low-Copper Pure Iron, Series B, Inland Steel Co	2.750	M	2.348	C	2.122	C	2.330	C	1.833	C	1.843	C	1.843	C	2.200	C
SS	Low-Copper Pure Iron, Series B, American Rolling Mill Co	2.625	M	2.281	C	2.143	C	2.250	C	1.750	VC	1.600	VC	1.650	VC	1.850	C
OO	Low-Copper Open-hearth Steel, Series A	2.511	C	2.234	C	2.643	M	2.281	C	2.083	C	2.600	M	2.350	C	2.800	M
CCC	Copper-Bearing Pure Iron, Series A	2.479	C	2.469	C	2.750	M	2.750	M	2.375	C	2.250	C	2.200	C	2.450	C
MM	Open-hearth Steel, Series B, Alan Wood Iron and Steel Co	2.348	C	2.330	C	2.663	M	2.929	M	2.964	M	3.043	M	3.200	M	3.400	S
ZZ(LC)	Low-Copper Steel, Series B, Youngstown Sheet and Tube Co	2.250	C	2.625	M	2.571	C	2.500	C	2.666	M	2.500	C	2.600	C	2.400	C
AA	Bessemer Steel, Series A	1.577	VC	1.771	VC	1.802	C	1.368	VC	1.333	VC	1.856	C	1.533	VC	1.953	C
YY[a]	Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co	.....	.....	2.625	M	2.143	C	2.125	C	2.333	C	2.200	C	1.800	VC	2.067	C

NOTE.—ZZ(HC) indicates copper 0.154 to 0.658 per cent.
ZZ(LC) indicates copper 0.031 per cent or under.
[a] YY Sheets exposed June 13, 1917.

TABLE V. (*continued*)—AVERAGE SURFACE TEXTURE, FORT SHERIDAN TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, AND APRIL, 1922. SHEETS EXPOSED APRIL 9, 1917.

Group.	Type Designation.	Date of Inspection.															
		Oct. 8, 1917.		April 8, 1918.		Mar. 31, 1919.		May 10, 1920.		Oct. 11, 1920.		April 4, 1921.		Oct. 17, 1921.		April 10, 1922.	
		Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
		No. 22 GAGE.															
Z(HC)	Copper-Bearing Steel, Series B, Youngstown Sheet and Tube Co.	3.985	S	4.271	VS	4.120	S	4.114	S	4.277	VS	4.100	S	3.883	S	4.067	S
I	Copper-Bearing Bessemer Steel, Series A	3.694	S	4.105	S	4.000	S	4.125	S	4.614	VS	4.600	VS	4.305	VS	4.968	VS
B	Open-hearth Steel, Series A	3.529	S	3.317	M	3.209	M	3.096	M	3.141	M	3.046	M	3.015	M	3.046	M
H	Copper-Bearing Basic Open-hearth Steel, Series A	3.500	S	3.625	S	3.402	S	3.716	S	3.576	S	3.600	S	3.490	S	3.945	S
T	Copper-Bearing Steel, Series B, Newport Rolling Mill Co.	3.447	S	3.625	S	3.479	S	3.545	S	3.429	S	3.686	S	3.157	M	3.443	S
K	Copper-Bearing Acid Open-hearth Steel, Series A	3.414	S	3.570	S	4.116	S	4.047	S	4.146	S	4.163	S	4.087	S	4.562	VS
V	Copper-Bearing Pure Iron, Series B, Whitaker-Glessner Co.	3.331	M	3.321	M	3.592	S	3.295	M	3.190	M	3.243	M	2.959	M	2.957	M
M	Open-hearth Steel, Series B, Alan Wood Iron and Steel Co.	3.295	M	3.232	M	3.061	M	3.468	M	3.393	M	3.229	M	3.185	M	3.828	S
C	Copper-Bearing Pure Iron, Series A	3.261	M	3.146	M	3.218	M	2.844	M	2.79[illegible]	M	2.800	M	2.200	C	2.400	C
D	Low-Copper Pure Iron, Series A	3.125	M	2.875	M	2.572	C	2.313	C	2.000	C	2.300	C	2.100	C	1.900	C
E	Puddled Iron, Series A	3.081	M	3.333	M	3.285	M	3.219	M	3.500	S	3.650	S	3.150	M	3.550	S
U	Copper-Bearing Pure Iron, Series B, Allegheny Steel Co.	2.884	M	2.875	M	3.122	M	3.071	M	3.059	M	3.086	M	2.659	M	2.957	M
S	Low-Copper Pure Iron, Series B, American Rolling Mill Co.	2.759	M	2.000	C	2.061	C	1.946	C	1.429	VC	1.557	VC	1.800	VC	1.088	VC
X	Low-Copper Pure Iron, Series B, Inland Steel Co.	2.536	C	2.250	C	2.316	C	2.098	C	2.059	C	1.846	C	2.000	C	1.554	VC
Z(LC)	Low-Copper Steel, Series B, Youngstown Sheet and Tube Co.	2.219	C	2.375	C	2.385	C	2.000	C	2.316	C	....	....	....	....	....	....
O	Low-Copper Open-hearth Steel, Series A	1.895	C	1.625	VC	1.857	C	1.386	VC	....		....	....	....	....	....	....
A	Bessemer Steel, Series A	1.584	VC	1.550	VC	1.828	C	1.56[illegible]	VC	1.69[illegible]	VC	1.600	VC	1.800	VC	1.400	VC
Y[a]	Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co.	....	....	2.708	M	2.095	C	2.375	C	2.35[illegible]	C	2.300	C	2.400	C	2.500	C

NOTE.—Z(HC) indicates copper 0.126 to 0.554 per cent.
Z(LC) indicates copper 0.020 per cent or under.

[a] Y Sheets exposed June 13, 1917. All of the O, and Z (LC) sheets exposed at Fort Sheridan are recorded as failures in this report, therefore no rating appears in this table.

The above table has been compiled from the composite inspection reports by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages and the scale for translating back into symbols are the same as given for Tables I to IV inclusive.

TABLE VI.—AVERAGE SURFACE TEXTURE, PITTSBURGH TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, AND APRIL, 1922. SHEETS EXPOSED DECEMBER 12, 1916.

Group.	Type Designation.	Date of Inspection.																	
		Oct. 9, 1917.		April 9, 1918.		Oct. 7, 1918.		April 1, 1919.		Nov. 5, 1919.		May 11, 1920.		Oct. 12, 1920.		April 5, 1921.		Oct. 18, 1921.	
		Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
	No. 16 GAGE.																		
HH	Copper-Bearing Basic Open-hearth Steel, Series A	3.725	S	3.600	S	4.025	S	3.883	S	4.044	S	3.896	S	4.009	S	3.967	S	3.833	S
ZZ(HC)	Copper-Bearing Steel, Series B, Youngstown Sheet and Tube Co.	3.684	S	4.266	VS	4.500	VS	4.267	VS	4.389	VS	4.333	VS	4.500	VS	4.466	VS	4.466	VS
II	Copper-Bearing Bessemer Steel, Series A	3.597	S	4.389	VS	4.431	VS	4.271	VS	4.666	VS	4.358	VS	4.825	VS	4.787	VS	4.750	VS
TT	Copper-Bearing Steel, Series B, Newport Rolling Mill Co.	3.572	S	3.589	S	3.982	S	4.071	S	3.690	S	3.666	S	3.939	S	3.452	S	3.595	S
KK	Copper-Bearing Acid Open-hearth Steel, Series A	3.428	S	4.171	S	4.177	S	4.178	S	4.140	S	4.053	S	4.458	VS	4.404	VS	4.439	VS
UU	Copper-Bearing Pure Iron, Series B, Allegheny Steel Co.	3.339	M	3.518	S	3.839	S	3.907	S	3.524	S	3.492	S	3.775	S	3.357	M	3.405	S
CCC	Copper-Bearing Pure Iron, Series A	3.219	M	3.333	M	3.333	M	3.130	M	3.333	M	3.074	M	2.988	M	3.111	M	2.944	M
EE	Puddled Iron, Series A	3.208	M	3.542	S	3.813	S	3.792	S	4.028	S	3.722	S	3.881	S	3.944	S	4.083	S
BB	Open-hearth Steel, Series A	3.100	M	3.037	M	2.860	M	2.941	M	3.010	M	2.752	M	2.904	M	2.647	M	2.990	M
VV	Copper-Bearing Pure Iron, Series B, Whitaker-Glessner Co	3.087	M	3.529	S	3.923	S	3.910	S	3.538	S	3.393	M	3.527	S	3.487	S	3.320	M
YY[a]	Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co	......	...	3.000	M	2.000	C	1.625	VC	1.333	VC	1.111	VC	1.000	VC	......	...	......	....
CC	Copper-Bearing Pure Iron, Series A	2.970	M	2.812	M	2.625	M	2.344	C	2.167	C	2.065	C	2.047	C	1.819	C	2.278	C
MM	Open-hearth Steel, Series B, Alan Wood Iron and Steel Co.	2.857	M	2.357	C	2.804	M	2.536	C	2.405	C	2.222	C	2.663	M	2.309	C	2.380	C
DD	Low-Copper Pure Iron, Series A	2.521	C	2.215	C	2.139	C	1.409	VC	1.528	VC	1.296	VC	1.127	VC	1.021	VC	1.531	VC
OO	Low-Copper Open-hearth Steel, Series A	2.167	C	1.500	VC	2.083	C	1.708	VC	1.833	C	1.407	VC	1.619	VC	1.333	VC	1.562	VC
ZZ(LC)	Low-Copper Steel, Series B, Youngstown Sheet and Tube Co	2.150	C	1.600	VC	2.375	VC	1.450	VC	2.067	C	......	....	......	....	......	...	......	....
XX	Low-Copper Pure Iron, Series B, Inland Steel Co.	1.996	C	1.750	VC	1.643	VC	1.482	VC	1.119	VC	......	....	......	....	......	...	......	....
SS	Low-Copper Pure Iron, Series B, American Rolling Mill Co.	1.822	C	1.625	VC	1.125	VC	1.000	VC	1.000	VC	......	....	......	....	......	...	......	....
AA	Bessemer Steel, Series A	1.162	VC	1.000	VC	1.037	VC	1.000	VC	1.143	VC	......	....	......	....	......	...	......	....

NOTE.—ZZ(HC) indicates copper 0.153 to 0.586 per cent.
ZZ(LC) indicates copper 0.034 per cent or under

[a] YY sheets exposed June 2, 1917.

TABLE VI (*Continued*).—AVERAGE SURFACE TEXTURE, PITTSBURGH TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, AND APRIL, 1922. SHEETS EXPOSED DECEMBER 12, 1916.

Group.	Type Designation.	Date of Inspection.																	
		Oct. 9, 1917.		April 9, 1918.		Oct. 7, 1918.		April 1, 1919.		Nov. 5, 1919.		May 11, 1920.		Oct. 12, 1920.		April 5, 1921.		Oct. 18, 1921.	
		Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
	NO. 22 GAGE.																		
Z(HC)	Copper-Bearing Steel, Series B, Youngstown Sheet and Tube Co.	3.828	S	4.008	S	4.294	VS	4.522	VS	4.294	VS	4.131	S	4.471	VS	4.033	S	4.400	VS
I	Copper-Bearing Bessemer Steel, Series A	3.819	S	4.118	S	4.472	VS	4.084	S	4.092	S	4.136	S	4.651	VS	4.556	VS	4.888	VS
H	Copper-Bearing Basic Open-hearth Steel, Series A	3.792	S	3.572	S	4.000	S	3.958	S	3.444	S	3.777	S	3.905	S	...	...	...	...
K	Copper-Bearing Acid Open-hearth Steel, Series A	3.719	S	4.062	S	4.187	S	4.188	S	3.833	S	4.083	S	4.428	VS	4.292	VS	4.333	VS
B	Open-hearth Steel, Series A	3.653	S	3.211	M	3.567	S	3.202	M	2.803	M	...	...	...	...	...	...	...	...
T	Copper-Bearing Steel, Series B, Newport Rolling Mill Co.	3.589	S	3.482	S	4.107	S	3.821	S	3.619	S	...	...	...	...	...	...	...	...
U	Copper-Bearing Pure Iron, Series B, Allegheny Steel Co.	3.554	S	3.232	M	3.875	S	3.696	S	3.548	S	...	...	...	...	...	...	...	...
V	Copper-Bearing Pure Iron, Series B, Whitaker-Glessner Co.	3.464	S	3.304	S	3.839	S	3.536	S	3.286	M	...	...	...	...	...	...	...	...
Y[a]	Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co.	...		3.250	M	2.500	C	1.625	VC	1.667	VC	...	...	...	...	...	...	...	...
C	Copper-Bearing Pure Iron, Series A	3.364	M	2.864	M	3.273	M	3.204	M	2.606	M	...	...	...	...	...	...	...	...
M	Open-hearth Steel, Series B, Alan Wood Iron and Steel Co.	3.330	M	3.107	M	2.732	M	3.108	M	3.238	M	...	...	...	...	...	...	...	...
E	Puddled Iron, Series A	3.125	M	3.250	M	3.385	M	3.270	M	3.062	M	...	...	...	...	...	...	...	...
D	Low-Copper Pure Iron, Series A	2.431	C	1.833	C	1.667	VC	1.333	VC	...	...	...	...	...	...	...	...	...	...
Z(LC)	Low-Copper Steel, Series B, Youngstown Sheet and Tube Co.	2.142	C	1.803	C	1.813	C	1.187	VC	1.000	VC	...	...	...	...	...	...	...	...
S	Low-Copper Pure Iron, Series B, American Rolling Mill Co.	1.893	C	1.625	VC	1.000	VC	1.000	VC	...	...	...	...	...	...	...	...	...	...
X	Low-Copper Pure Iron, Series B, Inland Steel Co.	1.491	VC	1.268	VC	1.214	VC	1.125	VC	...	...	...	...	...	...	...	...	...	...
A	Bessemer Steel, Series A	1.346	VC	1.000	VC	1.125	VC	1.029	VC	...	...	...	...	...	...	...	...	...	...
O	Low-Copper, Open-hearth Steel, Series A	1.209	VC	1.000	VC	1.091	VC	1.167	VC	...	...	...	...	...	...	...	...	...	...

NOTE.—Z(HC) indicates copper 0.128 to 0.712 per cent.
Z(LC) indicates copper 0.019 per cent or under.

[a] Y sheets exposed June 2, 1917.

In the case of the A, C, D, E, O, S, T, U, V, X, Y, Z(LC), AA, SS and ZZ(LC), recorded as complete failures in the 1919, 1920 and 1921 reports, no further detail record appears. All of the B, M, and YY, and a majority of the H and XX sheets exposed at Pittsburgh, Pa., are recorded as failures in this report, therefore no rating appears in this table.

The above table has been compiled from the composite inspection reports by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages and the scale used for translating back into symbols are the same as given for Tables I to IV inclusive.

burgh test rack. It will be noted that these two groups of sheets have substantially the same general composition, with the exception of the copper content, however the light gage copper-bearing sheets have no failures after 64 months exposure, whereas the heavier gage, non-copper-bearing sheets of approximately twice the thickness of the light gage copper-bearing sheets all failed after 24 months, exposure.

Fig. 47, Plate III, shows the general view of the Pittsburgh sheets as appearing on the rack at this inspection, marked in such manner as to locate each. All sheets that have failed prior to April 11, 1922, have been reported, and with few exceptions as noted have been photographed for permanent record.

Following the same general plan of presenting condensed results of various inspections, as in previous reports of the sub-committee, tables have been prepared from the composite reports for the inspections made during the past year.

Tables I, II, III and IV give in condensed form the results obtained by the averaging method for the condition of surface of sheets at Fort Sheridan, Pittsburgh and Annapolis in October, 1921, and at Fort Sheridan in April, 1922.

Tables V and VI present in condensed form the results obtained by the averaging method for the condition of surface texture of the sheets at Fort Sheridan and Pittsburgh for all inspections. By comparing this information with failures at these locations as shown in Tables VII and VIII it will be observed that the same groups of sheets have shown substantially the same surface texture development, and that the condition of surface texture continues to be a reliable guide as regarding rate of failure, the coarseness of texture usually accompanied by a light yellow, loose adhering rust, being apparently directly proportionate to increased rate of corrosion.

Table VII, Plate I, is presented as showing all sheets at the Fort Sheridan location grouped as regarding the presence of copper into copper-bearing and non-copper-bearing metals, the average analysis of all sheets at all three locations being the basis for classification. The table also shows the failures present in each group of sheets at all inspections, from which it will be observed that the sheets failing first at this location are confined to the non-copper-bearing metals, and belong to the same groups that failed first at Pittsburgh, which development indicates that the two different atmospheric conditions are showing the same general tendencies, only with varying rates of corrosion.

Table VIII, Plate II, is presented as a continuation of the same general plan of grouping the sheets at Pittsburgh as shown in Table XIII

TABLE VII.—FAILURES AT FORT SHERIDAN TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921 AND APRIL, 1922. SHE

Group.	Designation.	Series.	Description.	Average Analysis.					
				Carbon.	Manganese.	Phosphorus.	Sulfur.	Silicon.	Copp
									No. 16 GAGE SHEETS.
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.3
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.2
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.2
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.2
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.2
TT	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.080	0.313	0.009	0.020	0.006	0.2
UU	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.018	0.066	0.008	0.028	0.005	0.2
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.046	0.007	0.019	0.004	0.2
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.08	0.40	0.091	0.035	0.006	0.1
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.08	0.34	0.094	0.037	.....	0.2
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.36	0.082	0.033	.....	0.5
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.37	0.050	0.052	.....	0.1
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.09	0.34	0.038	0.077	0.003	0.6
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.39	0.049	0.044	.....	0.3
	Total	.....	.....	.....	.....	.....	.....	.....	...
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.0
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.1
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.0
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.0
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.0
MM	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" " "	0.017	0.414	0.010	0.029	0.007	0.0
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.017	0.021	0.006	0.021	0.006	0.0
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.062	0.008	0.030	0.005	0.0
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.051	0.123	0.019	0.203	0.0
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.08	0.45	0.102	0.037	0.008	0.0
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.022	0.39	0.040	0.028	.....	0.0
	Total	.....	.....	.....	.....	.....	.....	.....	...
									No. 22 GAGE SHEETS.
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.15
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.19
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.28
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.24
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.25
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.23
M	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" "	0.093	0.419	0.013	0.041	0.011	0.18
T	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.083	0.313	0.009	0.020	0.005	0.22
U	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.017	0.074	0.008	0.037	0.005	0.26
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.051	0.007	0.021	0.005	0.30
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.37	0.094	0.038	0.007	0.26
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.05	0.37	0.114	0.048	.....	0.53
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.35	0.049	0.059	.....	0.21
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.39	0.047	0.047	.....	0.28
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.41	0.042	0.042	.....	0.53
	Total	.....	.....	.....	.....	.....	.....	.....	...
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.01
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.10
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.14
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.02
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.02
S	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.02	0.023	0.006	0.022	0.004	0.02
X	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.021	0.055	0.007	0.031	0.004	0.02
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	" " "	0.03	0.055	0.139	0.021	0.218	0.02
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.07	0.44	0.107	0.046	0.003	0.01
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.06	0.38	0.077	0.035	0.009	0.13
Z	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.06	0.32	0.065	0.044	0.002	0.01
	Total	.....	.....	.....	.....	.....	.....	.....	...

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.
[a] No failures were recorded at inspections made prior to March 31, 1919; the detail records are accordingly not given here.

PLATE I.
PROC. AM. SOC. TEST. MATS.
VOL. 22, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

2. Sheets Exposed April 9, 1917. Comparing Copper-Bearing with Non-Copper-Bearing Materials.[1]

	Number of Sheets in Test.	Date of Inspection.							Number of Sheets Failed in Test.
Copper.		March 31, 1919.[a] 24 Months.	Dec. 6, 1919. 32 Months.	May 10, 1920. 37 Months.	Oct. 11, 1920. 42 Months.	April 4, 1921. 48 Months.	Oct. 17, 1921. 54 Months.	April 10, 1922. 60 Months.	
HEETS.									
0.319	12	None	None	None	None	None	None	None	None
0.237	17	None	None	None	None	None	None	None	None
0.247	19	None	None	None	None	None	None	None	None
0.234	19	None	None	None	None	None	None	None	None
0.236	12	None	None	None	None	None	None	None	None
0.223	14	None	None	None	None	None	None	None	None
0.239	13	None	None	None	None	None	None	None	None
0.299	19	None	None	None	None	None	None	None	None
0.154	1	None	None	None	None	None	None	None	None
0.279	2	None	None	None	None	None	None	None	None
0.528	2	None	None	None	None	None	None	None	None
0.172	2	None	None	None	None	None	None	None	None
0.641	2	None	None	None	None	None	None	None	None
0.318	2	None	None	None	None	None	None	None	None
.....	136	None	None	None	None	None	None	None	None
0.012	17	None	None	None	None	None	13 (1)	None	1
0.129	17	None	None	None	None	None	None	None	None
0.067	12	None	None	None	None	None	None	None	None
0.028	19	None	None	None	None	None	None	None	None
0.029	12	None	None	None	None	None	None	None	None
0.057	14	None	None	None	None	None	None	None	None
0.025	12	None	None	None	None	None	None	None	None
0.028	14	None	None	None	None	None	None	None	None
0.023	3	None	None	None	None	None	None	None	None
0.014	2	None	None	None	None	None	None	None	None
0.030	2	None	None	None	None	None	None	None	None
.....	124	None	None	None	None	None	1	None	1
EETS.									
0.156	2	None	None	None	None	None	None	None	None
0.195	10	None	None	None	None	None	None	None	None
0.283	12	None	None	None	None	None	None	None	None
0.244	11	None	None	None	None	None	None	None	None
0.252	19	None	None	None	None	None	None	None	None
0.237	16	None	None	None	None	None	None	None	None
0.185	14	None	None	None	None	None	None	None	None
0.227	14	None	None	None	None	None	None	None	None
0.260	14	None	None	None	None	None	None	None	None
0.304	14	None	None	None	None	None	None	None	None
0.263	2	None	None	None	None	None	None	None	None
0.533	2	None	None	None	None	None	None	None	None
0.212	2	None	None	None	None	None	None	None	None
0.286	2	None	None	None	None	None	None	None	None
0.532	2	None	None	None	None	None	None	None	None
.....	136	None	None	None	None	None	None	None	None
0.014	15	None	None	16, 17, 18 (3)	None	19, 29, 30 (3)	None	None	6
0.103	11	None	None	None	None	None	None	None	None
0.144	2	None	None	None	None	None	None	None	None
0.024	6	None	None	None	None	None	None	None	None
0.020	12	None	14, 15, 21 (3)	13, 16, 19, 23, 24 (5)	17, 18, 20, 22 (4)	....	....	....	12 (All)
0.022	14	None	None	None	None	None	16, 22, 25, 26, 28 (5)	17, 18, 19, 20, 21 23, 24, 27 (8)	13
0.027	14	None	None	None	None	25 (1)	None	None	1
0.020	3	None	None	None	4 (1)	None	None	None	1
0.011	2	None	None	None	None	4, 5 (2)	....	....	2 (All)
0.130	2	None	None	None	None	None	None	None	None
0.018	2	None	None	421 (1)	None	None	420 (1)	....	2 (All)
.....	83	None	3	9	5	6	6	8	37

aring.

TABLE VIII.—FAILURES AT PITTSBURGH TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921 AND APRIL, 1922. SHEE

Group.	Designation.	Series.	Description.	Average Analysis.						Number of Sheets in Test.	
				Carbon.	Man-ganese.	Phos-phorus.	Sulfur.	Silicon.	Copper.		Oct. 9, 10 Mo
No. 16 GAGE SHEET											
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319	12	No
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.237	15	No
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247	18	No
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234	19	No
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236	12	No
TT	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.080	0.313	0.009	0.020	0.006	0.223	14	No
UU	Copper-Bearing Pure Iron. Allegheny Steel Co.	B	" "	0.018	0.066	0.008	0.028	0.005	0.239	14	No
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.046	0.007	0.019	0.004	0.299	13	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.08	0.40	0.092	0.037	0.004	0.153	1	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.09	0.31	0.088	0.047	.....	0.271	3	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.36	0.085	0.033	.....	0.549	3	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.37	0.054	0.064	.....	0.223	3	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.09	0.33	0.032	0.056	0.003	0.575	3	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.40	0.056	0.048	.....	0.364	2	No
	Total	.....	.....	.....	.....	.....	.....	.....	.....	132	No
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012	17	No
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.113	17	No
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067	12	No
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028	18	No
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029	12	No
MM	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" " "	0.017	0.414	0.010	0.029	0.007	0.057	14	No
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025	14	No
XX	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028	14	No
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023	3	No
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.07	0.40	0.097	0.037	0.008	0.013	3	No
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.032	0.40	0.044	0.028	.....	0.028	2	No
	Total	.....	.....	.....	.....	.....	.....	.....	.....	126	No
No. 22 GAGE SHEETS.											
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.179	9	Non
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.190	9	Non
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283	12	Non
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244	12	Non
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252	18	Non
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237	16	Non
M	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" "	0.093	0.419	0.013	0.041	0.011	0.185	14	Non
T	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.083	0.313	0.009	0.020	0.005	0.227	14	Non
U	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.017	0.074	0.008	0.037	0.005	0.260	14	Non
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.051	0.007	0.021	0.005	0.304	14	Non
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.039	0.37	0.084	0.038	0.007	0.257	3	Non
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.043	0.37	0.100	0.045	.....	0.533	2	Non
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.35	0.049	0.059	.....	0.212	3	Non
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.39	0.059	0.058	.....	0.268	3	Non
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.41	0.050	0.050	.....	0.621	3	Non
	Total	.....	.....	.....	.....	.....	.....	.....	.....	146	Non
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014	17	Non
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.082	4	Non
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.139	2	Non
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024	9	Non
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020	12	Non
S	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022	14	Non
X	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027	14	Non
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020	3	Non
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.055	0.37	0.119	0.048	0.003	0.013	3	Non
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.07	0.40	0.088	0.048	0.009	0.133	3	Non
Z	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.10	0.32	0.069	0.044	0.002	0.018	3	Non
	Total	.....	.....	.....	.....	.....	.....	.....	.....	84	Non

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent as copper-bearing.

[2] These "Y" Sheets were reported as failures at the Nov. 5, 1919, inspection, but are placed in this column because they were exposed about six months later than all other sheets.

PLATE II.
PROC. AM. SOC. TEST. MATS.
VOL. 22, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

SHEETS EXPOSED DECEMBER 12, 1916. COMPARING COPPER-BEARING WITH NON-COPPER-BEARING MATERIALS.[1]

Date of Inspection.										Number of Sheets Failed in Test.
Oct. 9, 1917. 10 Months.	April 9, 1918. 16 Months.	Oct. 7, 1918. 22 Months.	April 1, 1919. 28 Months.	Nov. 5, 1919. 35 Months.	May 11, 1920. 41 Months.	Oct. 12, 1920. 46 Months.	April 5, 1921. 52 Months.	Oct. 18, 1921. 58 Months.	April 11, 1922. 64 Months	
SHEETS.										
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None
None	None	None	25, 26,27, 28, 29 30, 50, 51, 52, 53 54, 55, 56 (13)	21, 22, 23, 24 (4)	....	.....	....	....	....	17 (All)
None	None	None	None	None	None	None	None	23 (1)	20, 21 (2)	3
None	None	None	None	None	None	None	None	18 (1)	15, 17 (2)	3
None	None	None	None	None	None	None	25, 26 (2)	27, 28, 29, 30, 31 54, 55, 57, 58 (9)	8, 9, 49 (3)	14
None	None	None	None	None	None	27 (1)	25, 26, 28, 33 (4)	29, 30, 31, 34, 35 36 (6)	None	11
None	None	None	None	None	None	None	None	29, 30, 35, 38, 40 (5)	41 (1)	6
None	None	None	None	None	29, 30, 31, 32, 33 35, 39, 40 (8)	34, 36, 37, 38, 41 42 (6)	....	....	....	14 (All)
None	None	None	None	None	29, 30, 31, 32 41 (5)	36 (1)	33, 34, 35, 38 39, 40 (6)	37, 42 (2)	....	14 (All)
None	None	None	None	None	None	None	7, 9 (2)	8 (1)	....	3 (All)
None	None	None	None	8, 10, 14 (3)	....	....	....	....	....	3 (All)
None	None	None	None	None	None	None	None	None	None	None
None	None	None	13	7	13	8	14	25	8	88
SHEETS.										
None	None	None	None	17 (1)	18 (1)	21, 23 (2)	22, 34, 39 (3)	19, 20 (2)	....	9 (All)
None	None	None	None	11, 13, 14, 22 (4)	32, 34, 35 (3)	33 (1)	12 (1)	....	....	9 (All)
None	None	32, 36 (2)	29, 30, 31, 35 (4)	25, 27, 33, 34 (4)	26, 28 (2)	....	....	....	....	12 (All)
None	None	None	None	None	None	None	38, 40, 42, 45, 49 50, 53, 54, 55 (9)	47 (1)	43 (1)	11
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	36, 41 (2)	37, 39 (2)	4
None	None	None	None	None	32, 36, 42 (3)	39, 41 (2)	29, 30, 33, 34, 35 37, 38, 40 (8)	31 (1)	....	14 (All)
None	None	None	None	37, 39 (2)	32, 33, 35 36, 38 (5)	29, 30, 31, 34, 40 41, 42 (7)	....	....	....	14 (All)
None	None	None	None	41 (1)	29, 30, 40 (3)	31, 33, 34, 35, 38 42 (6)	32, 36, 37 39 (4)	....	....	14 (All)
None	None	None	None	29, 39 (2)	36, 37, 42 (3)	30, 33, 34, 35, 38 40, 41 (7)	31, 32 (2)	....	....	14 (All)
None	None	None	None	None	None	None	None	None	214 (1)	1
None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	509, 513, 516 (3)	....	3 (All)
None	None	None	None	None	None	None	None	607, 608, 609 (3)	....	3 (All)
None	None	None	None	None	None	None	715 (1)	None	714 (1)	2
None	None	2	4	14	20	25	28	12	5	110
None	31, 32, 33, 34, 35 36, 37, 38, 40, 41 42, 43, 44, 45, 46 47 (16)	39 (1)	....	....	....	....	....	....	....	17 (All)
None	None	37 (1)	38 (1)	35 (1)	36 (1)	....	....	....	....	4 (All)
None	None	None	None	20 (1)	21 (1)	....	....	....	....	2 (All)
None	None	30, 36, 38 (3)	31, 33, 34, 35 39, 40 (6)	....	....	....	....	....	....	9 (All)
None	25, 26, 27, 28, 29 30, 31, 32, 33, 34 35, 36 (12)	....	....	....	....	....	....	....	....	12 (All)
None	35 (1)	29, 30, 31, 32, 33 34, 36, 37, 38, 39 40, 41, 42 (13)	....	....	....	....	....	....	....	14 (All)
None	None	29, 30, 31, 32, 33 34, 35, 36, 37,38 39,40,41,42 (14)	....	....	....	....	....	....	....	14 (All)
None	None	None	7, 8, 9 (3)[2]	....	....	....	....	....	....	3 (All)
None	11 (1)	6, 7 (2)	....	....	....	....	....	....	....	3 (All)
None	None	None	None	None	None	None	113 (1)	None	None	1
None	None	122, 423, 424 (3)	....	....	....	....	....	....	....	3 (All)
None	30	37	10	2	2	None	1	None	None	82

ts.

TABLE IX.—AVERAGE COMPOSITIONS OF GROUPS OF SHEETS OF PITTSBURGH TESTS THAT HAVE COMPLETELY FAILED. SHEETS EXPOSED DECEMBER 12, 1916.

Group.	Type Designation.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.
A 31–47	No. 22 Gage Bessemer Steel, Series A	0.038	0.386	0.089	0.040	0.007	0.014
B 35–38	No. 22 Gage Open-hearth Steel, Series A	0.09	0.38	0.017	0.062	0.036	0.082
B 17–23 B 34–39	No. 22 Gage Open-hearth Steel, Series A	0.06	0.27	0.014	0.053	0.006	0.179
C 11–14 C 32–35	No. 22 Gage Copper-Bearing Pure Iron, Series A	0.015	0.028	0.006	0.036	0.003	0.190
C 20–22	No. 22 Gage Copper-Bearing Pure Iron, Series A	0.01	0.028	0.002	0.027	0.002	0.139
D 30–40	No. 22 Gage Low-Copper Pure Iron, Series A	0.020	0.026	0.004	0.022	0.002	0.024
E 25–36	No. 22 Gage Puddled Iron, Series A	0.033	0.034	0.114	0.021	0.134	0.283
M 29–42	No. 22 Gage Open-hearth Steel, Series B, Alan Wood Iron and Steel Co	0.093	0.419	0.013	0.041	0.011	0.185
O 25–36	No. 22 Gage Open-hearth Steel, Series A	0.121	0.536	0.008	0.030	0.249	0.020
S 29–42	No. 22 Gage Low-Copper Pure Iron, Series B, American Rolling Mill Co	0.020	0.023	0.006	0.022	0.004	0.022
T 29–42	No. 22 Gage Copper-Bearing Steel, Series B, Newport Rolling Mill Co	0.083	0.313	0.009	0.020	0.005	0.227
U 29–42	No 22 Gage Copper-Bearing Pure Iron, Series B, Allegheny Steel Co	0.017	0.074	0.008	0.037	0.005	0.260
V 29–42	No. 22 Gage Copper-Bearing Pure Iron, Series B, Whittaker-Glessner Co	0.018	0.051	0.007	0.021	0.005	0.304
X 29–42	No. 22 Gage Low-Copper Pure Iron, Series B, Inland Steel Co	0.021	0.055	0.007	0.031	0.004	0.027
Y 7–9[a]	No. 22 Gage Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co	0.03	0.055	0.139	0.021	0.218	0.020
Z 6, 7, 11	No. 22 Gage Bessemer Steel, Series B, Youngstown Sheet and Tube Co	0.055	0.37	0.119	0.048	0.003	0.013
Z 422, 423, 424	No. 22 Gage Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.10	0.32	0.069	0.044	0.002	0.018
Z 509, 513, 516	No. 22 Gage Copper-Bearing Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.06	0.35	0.049	0.059	.....	0.212
Z 607, 608, 609	No. 22 Gage Copper-Bearing Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.07	0.39	0.059	0.058	.....	0.268
AA 21–30 AA 50–56[b]	No. 16 Gage Bessemer Steel, Series A. No. 16 Gage Bessemer Steel, Series A.	0.043	0.419	0.083	0.042	0.004	0.012
SS 29–42	No. 16 Gage Low-Copper Pure Iron, Series B, American Rolling Mill Co	0.017	0.021	0.006	0.021	0.006	0.025
XX 29–42	No. 16 Gage Low-Copper Pure Iron, Series B, Inland Steel Co	0.021	0.062	0.008	0.030	0.005	0.028
ZZ 8, 10, 14	No. 16 Gage Bessemer Steel, Series B, Youngstown Sheet and Tube Co	0.07	0.40	0.097	0.037	0.008	0.013
YY 7, 8, 9	No. 16 Gage Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co	0.03	0.051	0.123	0.019	0.203	0.023

[a] Y Sheets exposed June 2, 1917.
[b] AA Sheets 50–56 sand blasted.

TABLE X.—AVERAGE COMPOSITIONS OF GROUPS OF SHEETS OF FORT SHERIDAN TESTS THAT HAVE COMPLETELY FAILED. SHEETS EXPOSED APRIL 9, 1917.

Group.	Type Designation.	Carbon per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper per cent.
O 13–24	No. 22 Gage Low-Copper Open-hearth Steel, Series A	0.121	0.536	0.008	0.030	0.249	0.020
Z 4, 5	No. 22 Gage Bessemer Steel, Series B, Youngstown Sheet and Tube Co	0.07	0.44	0.107	0.046	0.003	0.011
Z 420, 421	No. 22 Gage Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.06	0.32	0.065	0.044	0.002	0.018

of the 1921 report, recording such additional failures as have occurred during the past year. It will be observed that practically all of the light gage non-copper-bearing sheets failed after 28 months' exposure, whereas only 6 of the 146 copper-bearing sheets had failed at that time. At the end of 64 months' exposure there still remains two full groups of copper-bearing sheets. as well as 18 other scattered copper bearing sheets with no failures. The heavy gage non-copper-bearing sheets now show 87 of the total 126 sheets failed, five groups showing entire failures, whereas none of the 132 copper-bearing sheets has failed at this time. This information continues to bear out the conclusions of the 1921 report that copper-bearing metal in the Pittsburgh location shows marked superiority in rust resisting properties as compared to non-copper-bearing metal of the same general composition.

Table IX is presented as the continuation of Table XIV of the 1921 report, showing in condensed form the composition of groups of sheets that have completely failed at the Pittsburgh location, adding such additional groups as have failed during the past year. No further detail record for these sheets will appear in future reports.

At the Fort Sheridan location three entire groups of sheets have completely failed, and following the same general plan as appearing for the Pittsburgh failures in previous reports, Table X is presented as showing in condensed form the average composition of such groups as have completely failed at this location. No further detail record for these sheets will appear in future reports.

THIRD MEETING.

The third meeting of the sub-committee was held at Pittsburgh on April 11, 1922, at which time the report of the sub-committee was considered and unanimously approved.

Respectfully submitted on behalf of the sub-committee,

J. H. GIBBONEY,
Chairman.

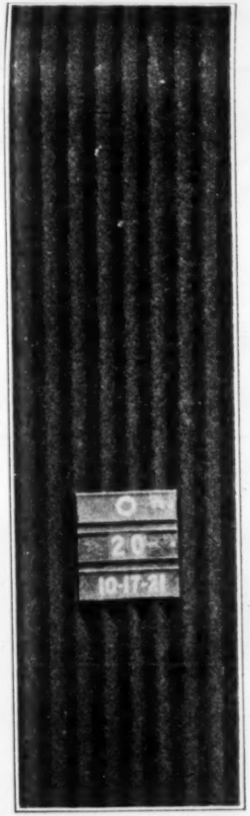


FIG. 1.—FORT SHERIDAN TESTS.
NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL —SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
O 20. .	0.11	0.57	0.008	0.035	0.236	0.026	. . . .

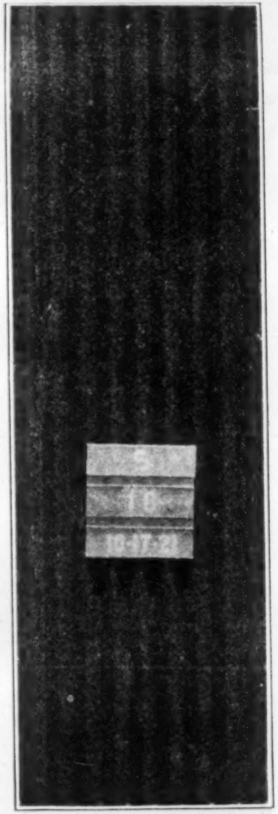


FIG. 2.—FORT SHERIDAN TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
AMERICAN ROLLING MILL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
S 16.	0.014	0.016	0.011	0.018	None	0.017	0.049

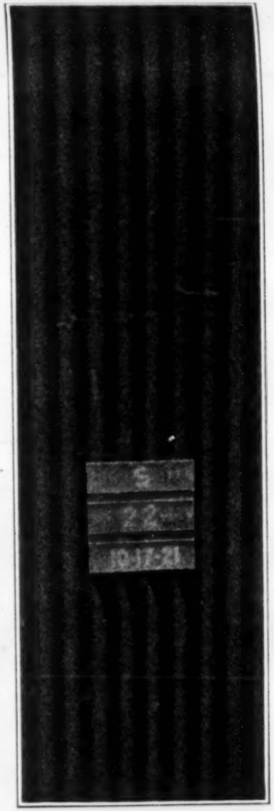


FIG. 3.—FORT SHERIDAN TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
AMERICAN ROLLING MILL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
S 22.	0.015	0.02	0.006	0.022	. . . .	0.02	. . . .

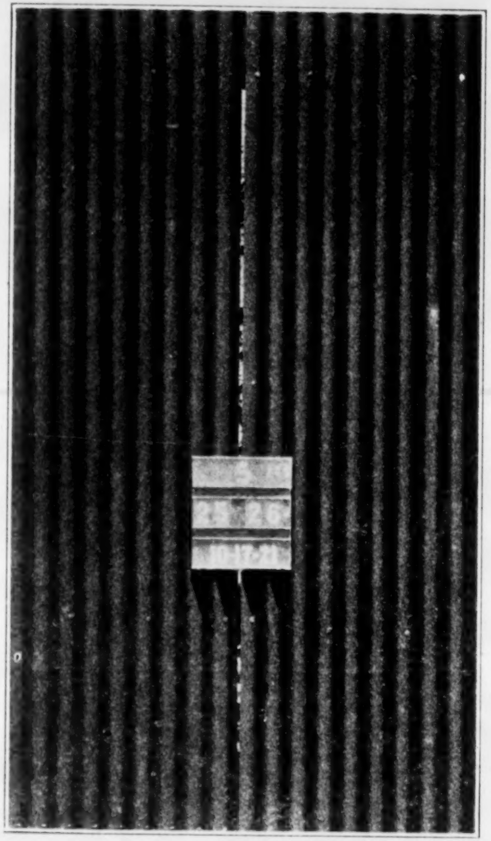


FIG. 4.—FORT SHERIDAN TESTS.
NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
AMERICAN ROLLING MILL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
S 25....	0.014	0.015	0.010	0.026	....	0.02	....
S 26....	0.015	0.015	0.007	0.024	....	0.02	....

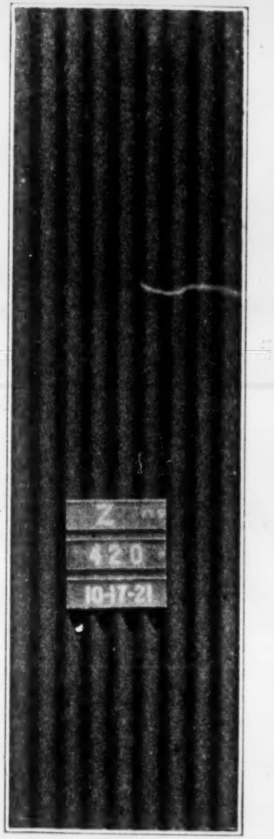


FIG. 5.—FORT SHERIDAN TESTS.
NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES B.
YOUNGSTOWN SHEET AND TUBE CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 420...	0.032	0.33	0.060	0.041	....	0.020	....

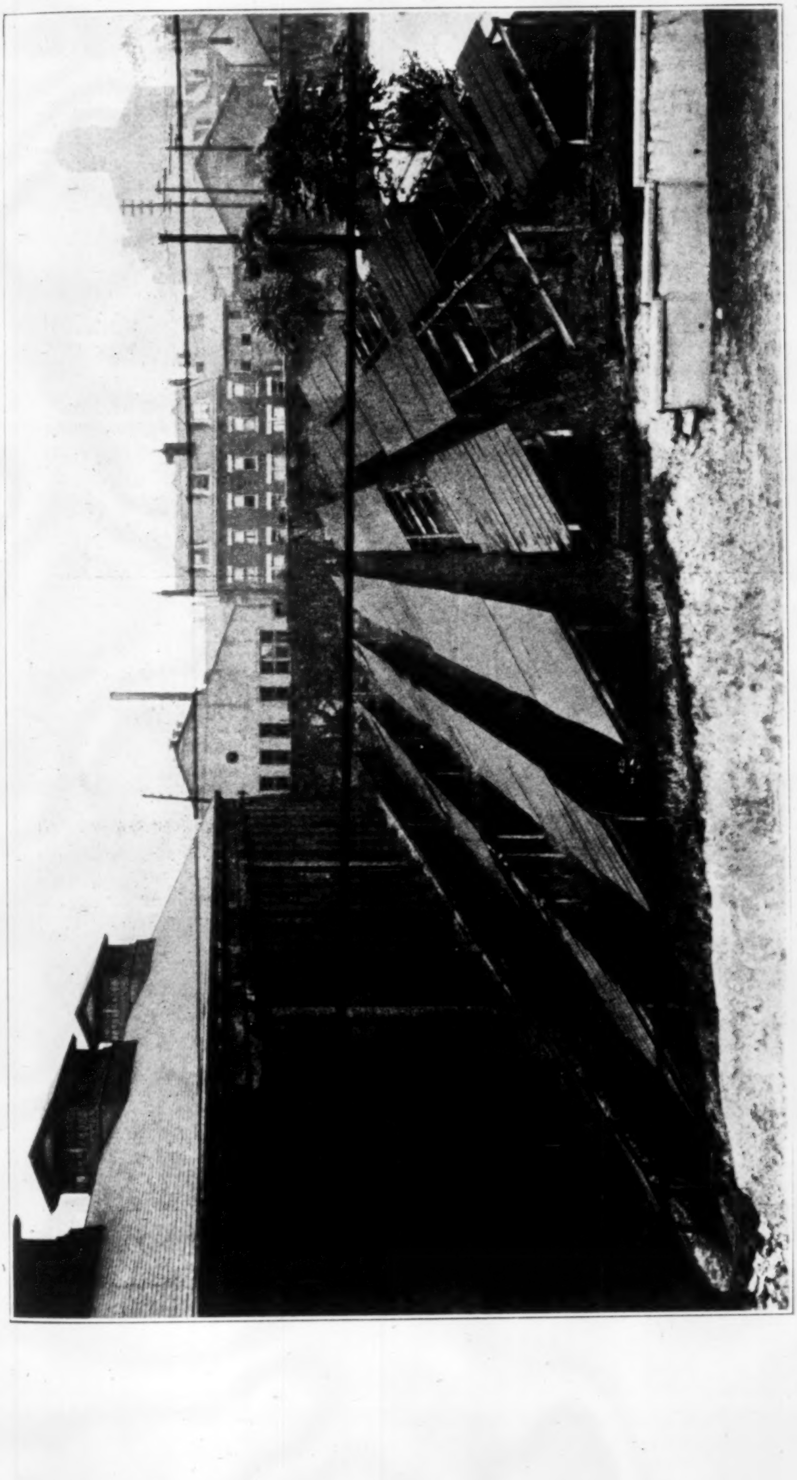


FIG. 6.—GENERAL VIEW OF PITTSBURGH TEST RACK. October 18, 1921.

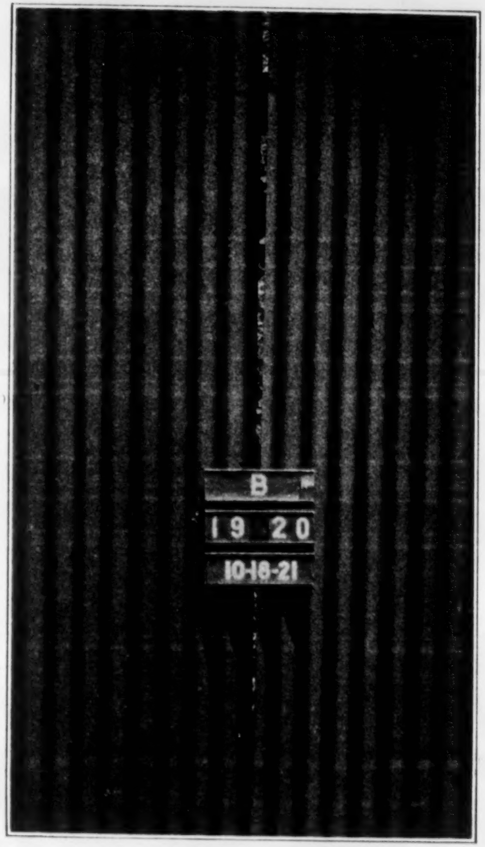


FIG. 7.—PITTSBURGH TESTS.
NO. 22 GAGE OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.]
B 19....	0.04	0.23	0.005	0.051	0.003	0.175	....
B 20....	0.05	0.23	0.006	0.052	0.003	0.172	....

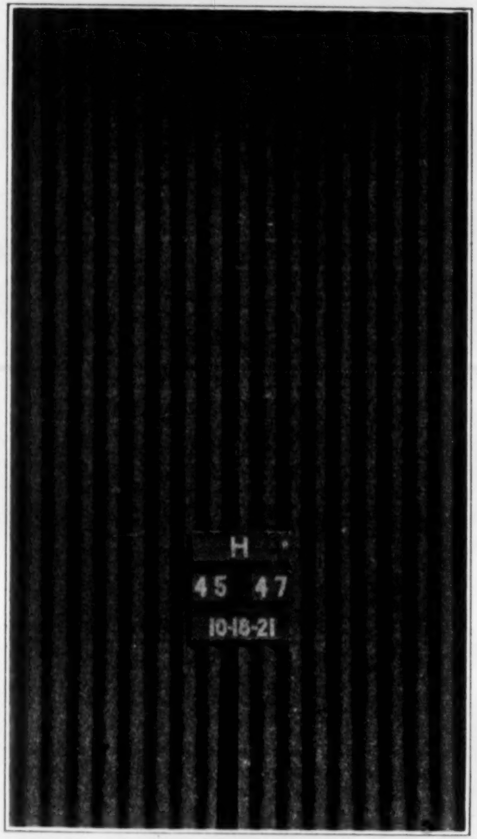


FIG. 8.—PITTSBURGH TESTS.
NO. 22 GAGE COPPER-BEARING BASIC OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
H 45....	0.06	0.38	0.013	0.029	....	0.23	0.030
H 47....	0.06	0.38	0.011	0.026	....	0.21	0.025

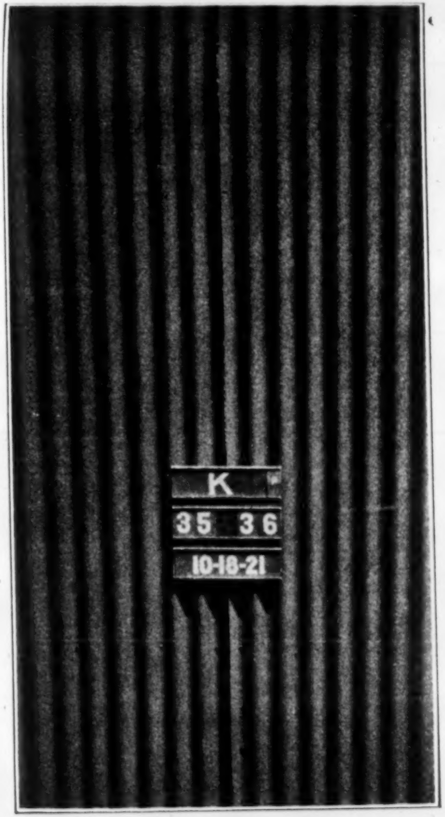


FIG. 9.—PITTSBURGH TESTS.
No. 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 35....	0.13	0.47	0.104	0.050	....	0.25	....
K 36....	0.11	0.47	0.092	0.036	....	0.25	....

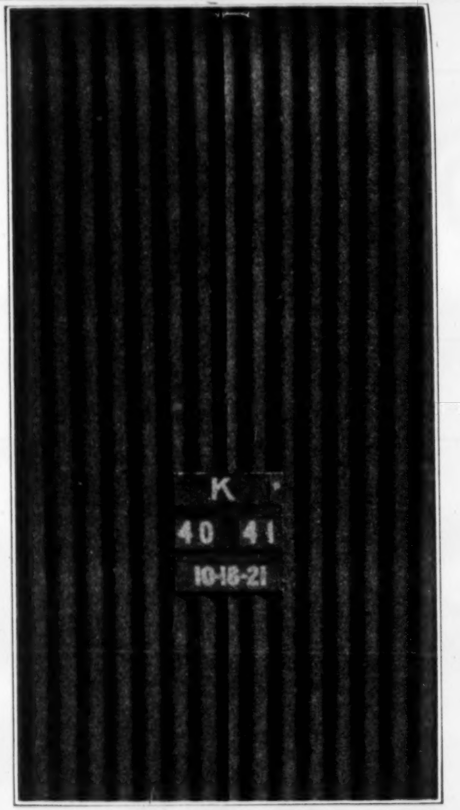


FIG. 10.—PITTSBURGH TESTS.
No. 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 40....	0.09	0.45	0.108	0.053	....	0.23	....
K 41....	0.09	0.46	0.090	0.044	....	0.23	....

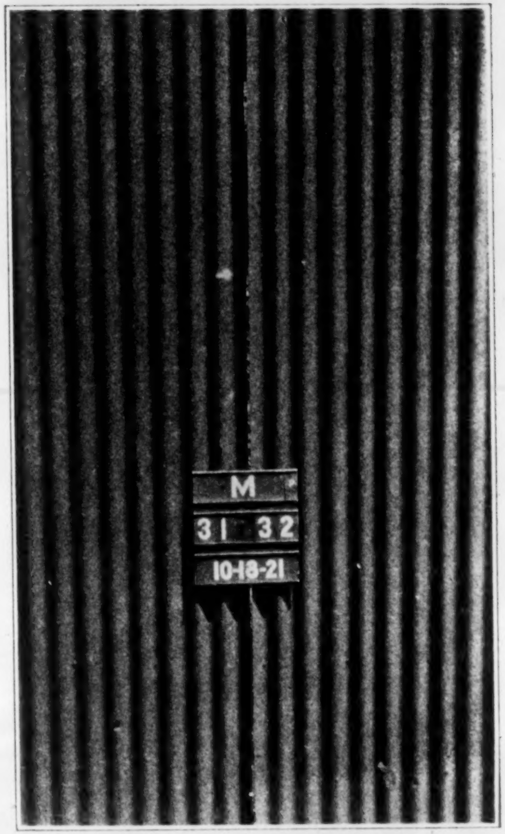


FIG. 11.—PITTSBURGH TESTS.
NO. 22 GAGE OPEN-HEARTH STEEL—SERIES B.
ALAN WOOD IRON AND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
M 31....	0.11	0.52	0.005	0.047	....	0.178	None
M 32....	0.10	0.52	0.007	0.051	....	0.16	None

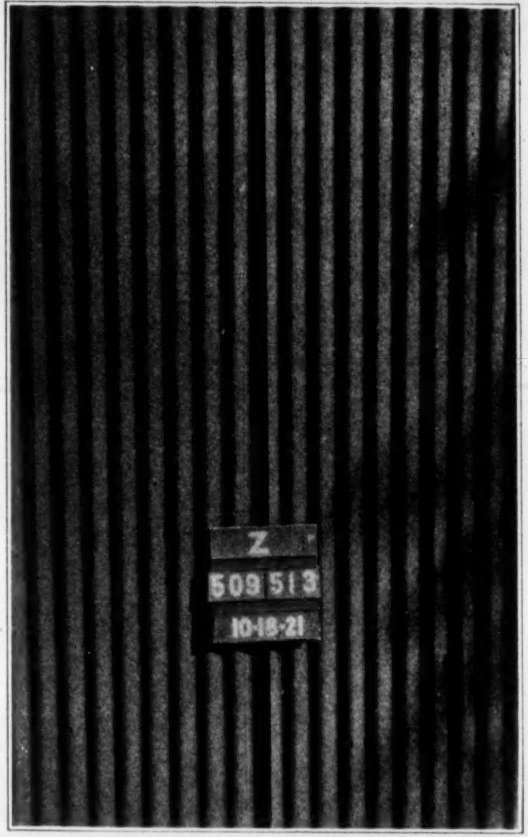


FIG. 12.—PITTSBURGH TESTS.
NO. 22 GAGE COPPER-BEARING OPEN-HEARTH STEEL—SERIES B.
YOUNGSTOWN SHEET AND TUBE CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 509...	0.06	0.36	0.044	0.051	....	0.174	None
Z 513...	0.06	0.34	0.047	0.057	....	0.204	None

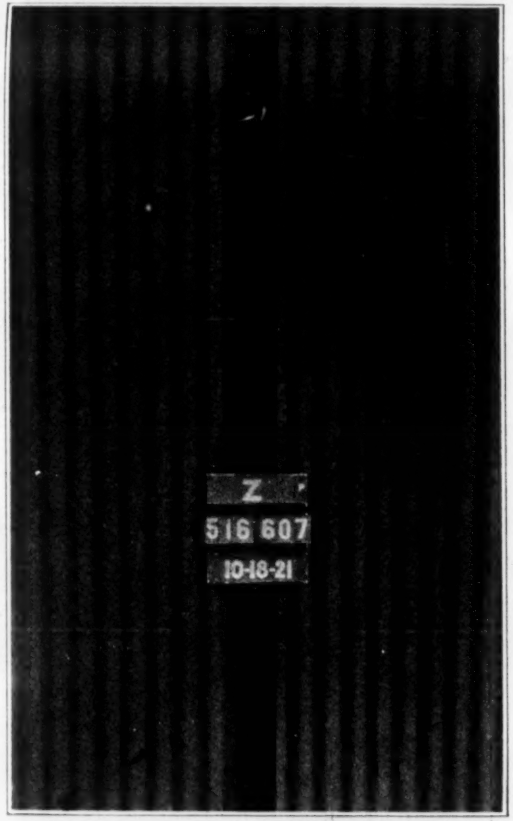


FIG. 13.—PITTSBURGH TESTS.
No. 22 GAGE COPPER-BEARING OPEN-HEARTH STEEL—SERIES B.
YOUNGSTOWN SHEET AND TUBE CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 516 . . .	0.06	0.34	0.056	0.070	. . . .	0.257	None
Z 607 . . .	0.07	0.40	0.070	0.069	Trace	2.282	None

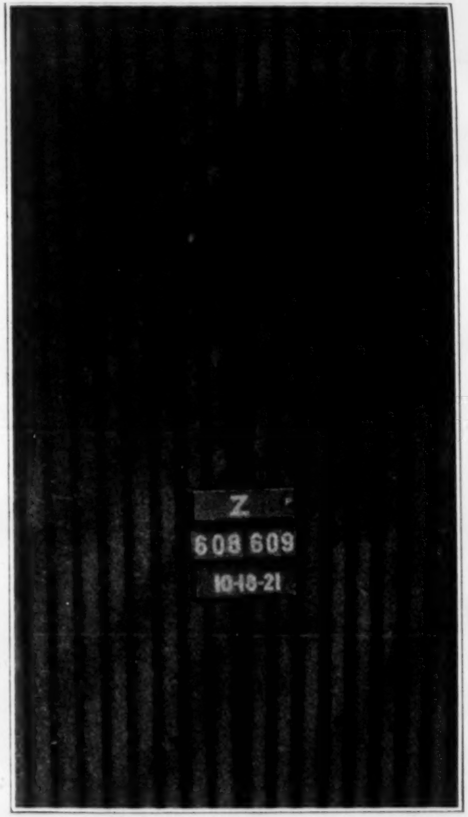


FIG. 14.—PITTSBURGH TESTS.
No. 22 GAGE COPPER-BEARING OPEN-HEARTH STEEL—SERIES B.
YOUNGSTOWN SHEET AND TUBE CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 608 . . .	0.07	0.38	0.046	0.044	Trace	0.266	None
Z 609 . . .	0.08	0.40	0.060	0.062	Trace	0.256	None

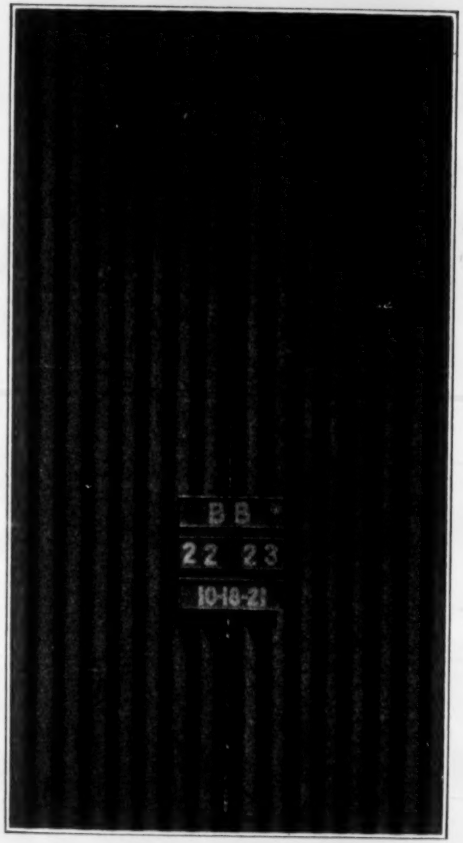


FIG. 15.—PITTSBURGH TESTS.
No. 16 GAGE OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
BB 22...	0.083	0.486	0.016	0.028	0.004	0.03	....
BB 23...	0.06	0.49	0.024	0.028	0.009	0.041	....

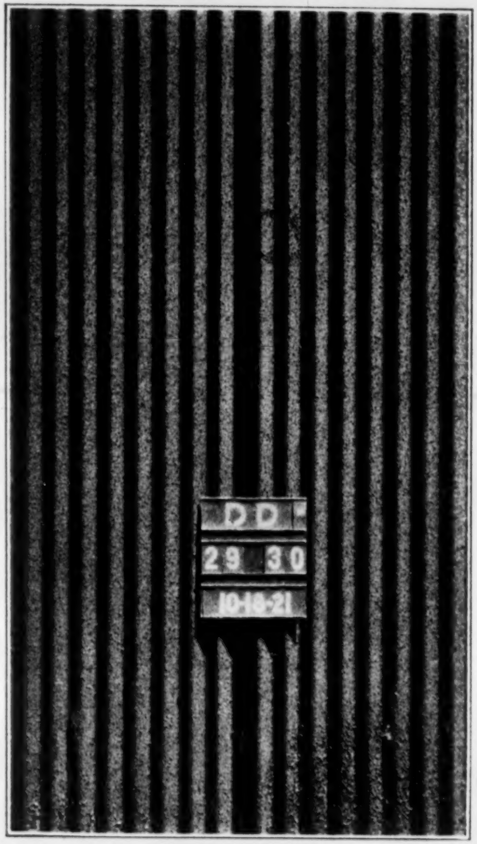


FIG. 16.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 29..	0.01	0.016	0.003	0.026	0.006	0.032	....
DD 30..	0.01	0.016	0.003	0.029	0.006	0.038	....

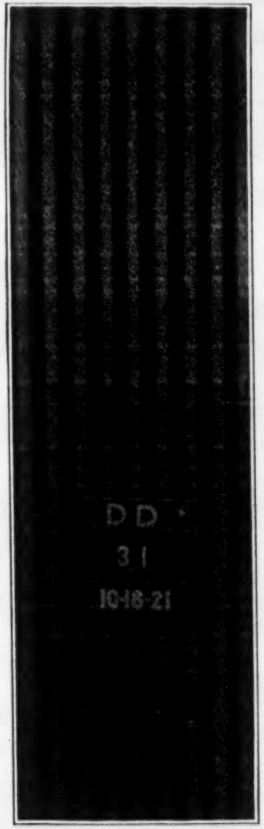


FIG. 17.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 31..	0.01	0.016	0.003	0.028	0.006	0.035	....

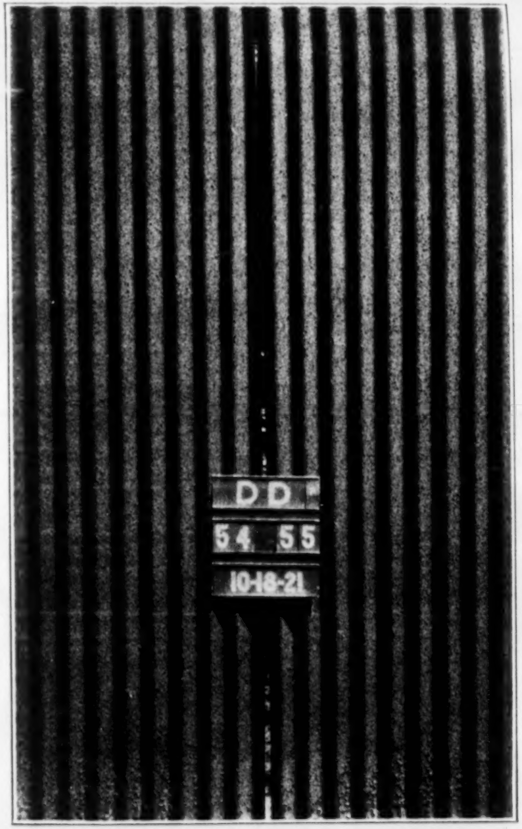


FIG. 18.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 54..	0.02	0.02	0.006	0.024	....	0.02	....
DD 55..	0.02	0.02	0.005	0.024	....	0.018	....

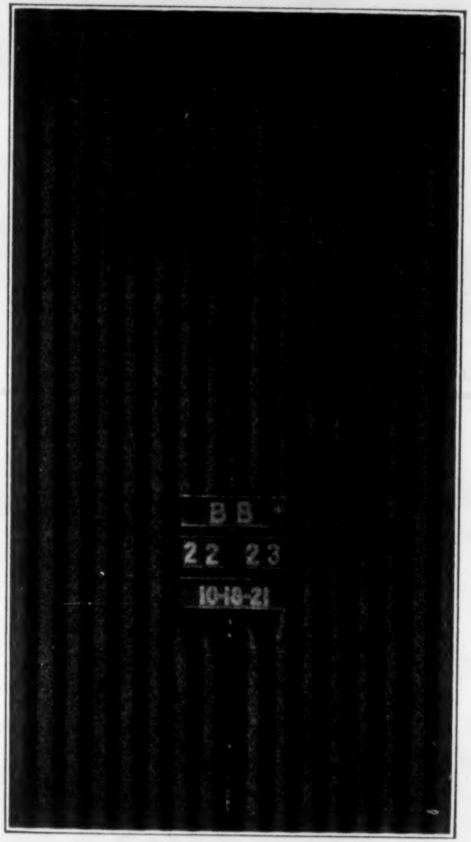


FIG. 15.—PITTSBURGH TESTS.
No. 16 GAGE OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
BB 22...	0.083	0.486	0.016	0.028	0.004	0.03	....
BB 23...	0.06	0.49	0.024	0.028	0.009	0.041	....

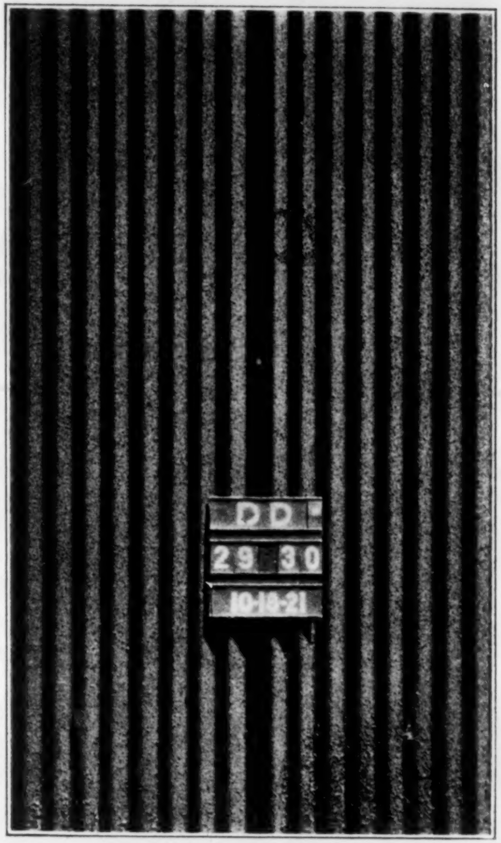


FIG. 16.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 29..	0.01	0.016	0.003	0.026	0.006	0.032	....
DD 30..	0.01	0.016	0.003	0.029	0.006	0.038	....

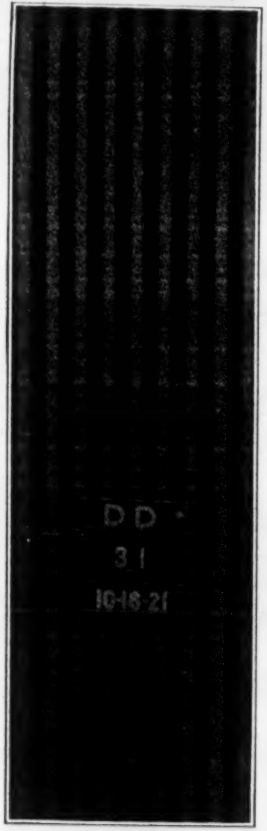


FIG. 17.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 31..	0.01	0.016	0.003	0.028	0.006	0.035	....

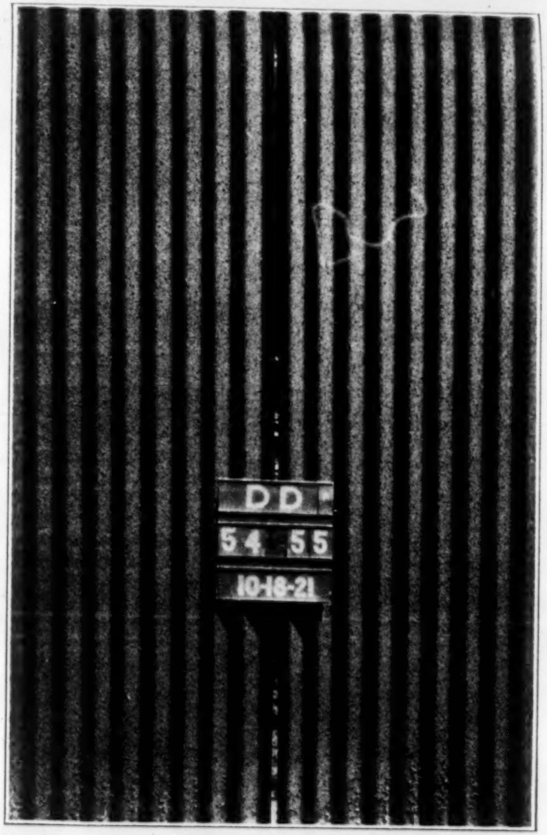


FIG. 18.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 54..	0.02	0.02	0.006	0.024	....	0.02	....
DD 55..	0.02	0.02	0.005	0.024	....	0.018	....

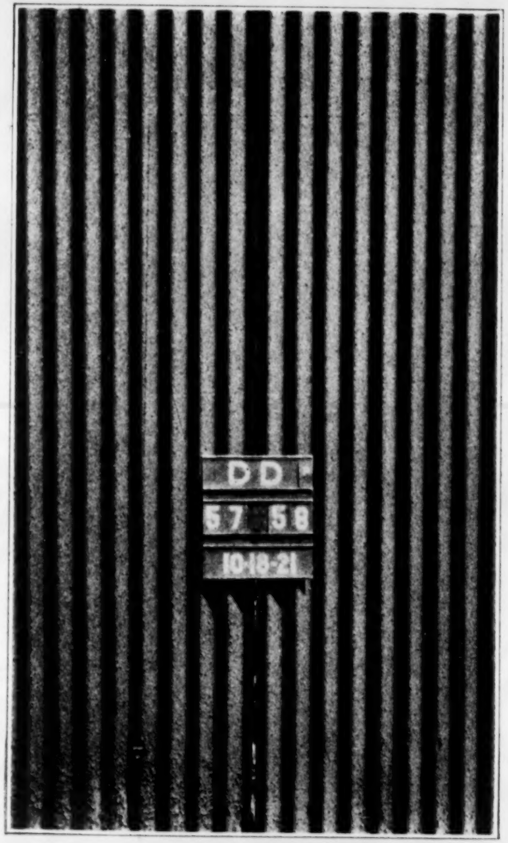


FIG. 19.—PITTSBURGH TESTS.
NO. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 57..	0.02	0.02	0.004	0.021	....	0.018	....
DD 58..	0.01	0.03	0.004	0.024	0.004	0.012	....

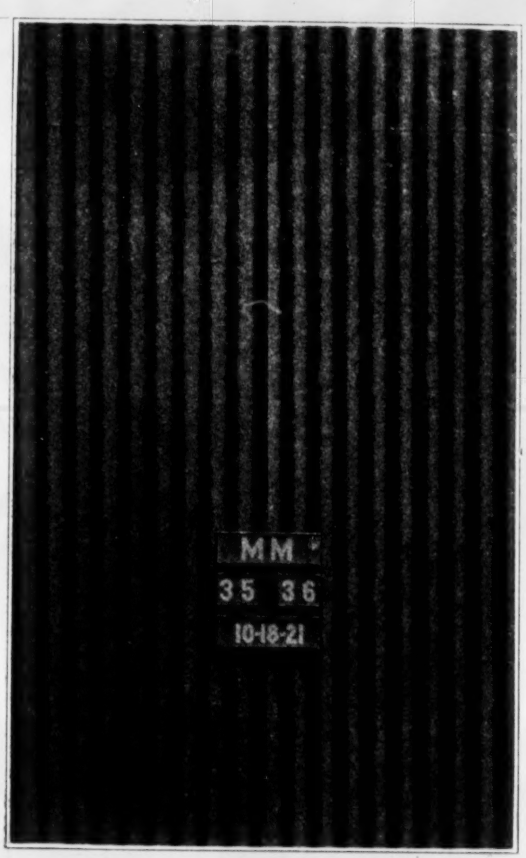


FIG. 20.—PITTSBURGH TESTS.
NO 16. GAGE OPEN-HEARTH STEEL—SERIES B.
ALAN WOOD IRON AND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 35..	0.10	0.44	0.015	0.032	0.006	0.055	None
MM 36..	0.085	0.45	0.012	0.030	0.005	0.055	None

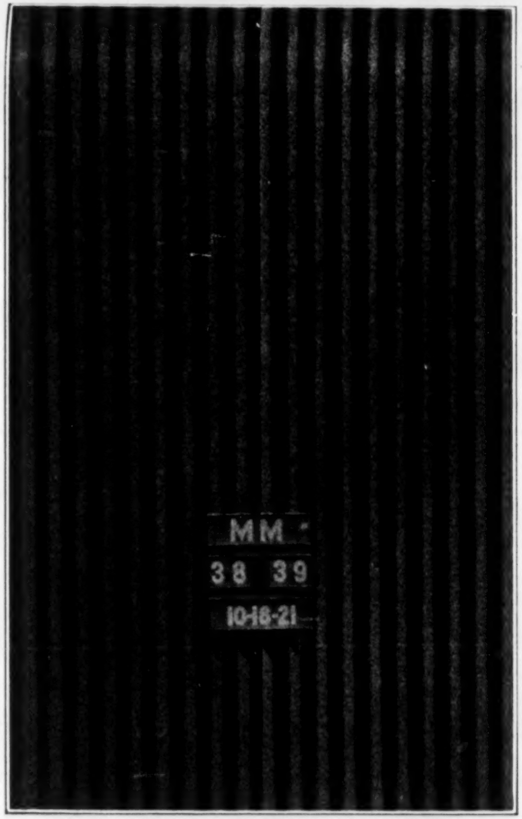


FIG. 21.—PITTSBURGH TESTS.
No. 16 GAGE OPEN-HEARTH STEEL—SERIES B.
ALAN WOOD IRON AND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 38..	0.06	0.45	0.009	0.030	0.005	0.055	None
MM 39..	0.105	0.42	0.011	0.031	0.005	0.050	None

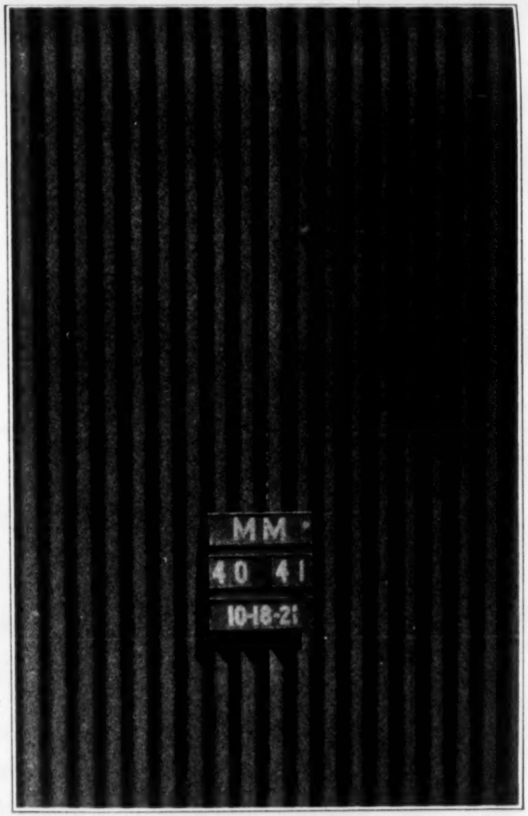


FIG. 22.—PITTSBURGH TESTS.
No. 16 GAGE OPEN-HEARTH STEEL—SERIES B.
ALAN WOOD IRON AND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 40..	0.105	0.44	0.011	0.029	0.005	0.055	None
MM 41..	0.115	0.42	0.012	0.032	0.005	0.08	None

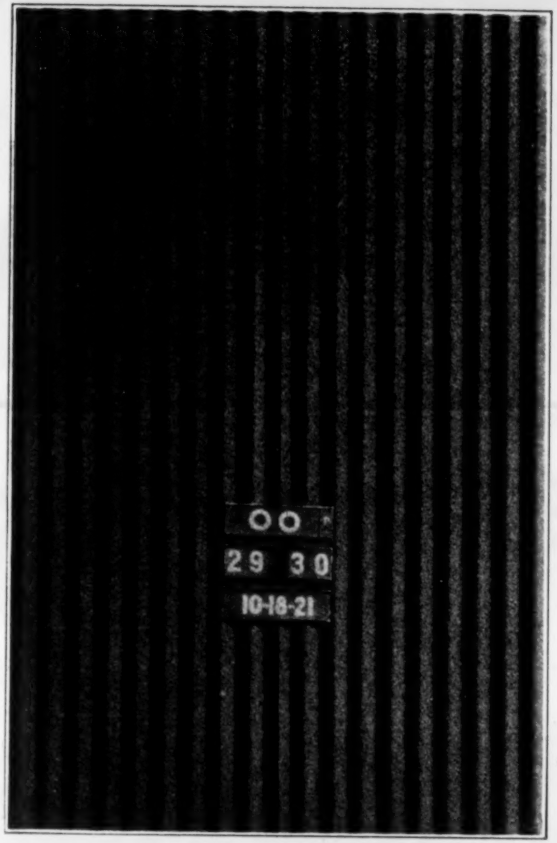


FIG. 23.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
OO 29...	0.12	0.38	0.006	0.027	0.006	0.024	Trace
OO 30...	0.12	0.37	0.006	0.027	0.005	0.032	Trace

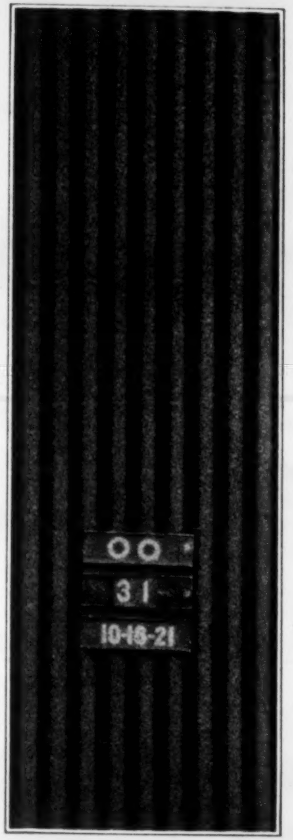


FIG. 24.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
OO 31...	0.11	0.37	0.008	0.025	0.005	0.028	Trace

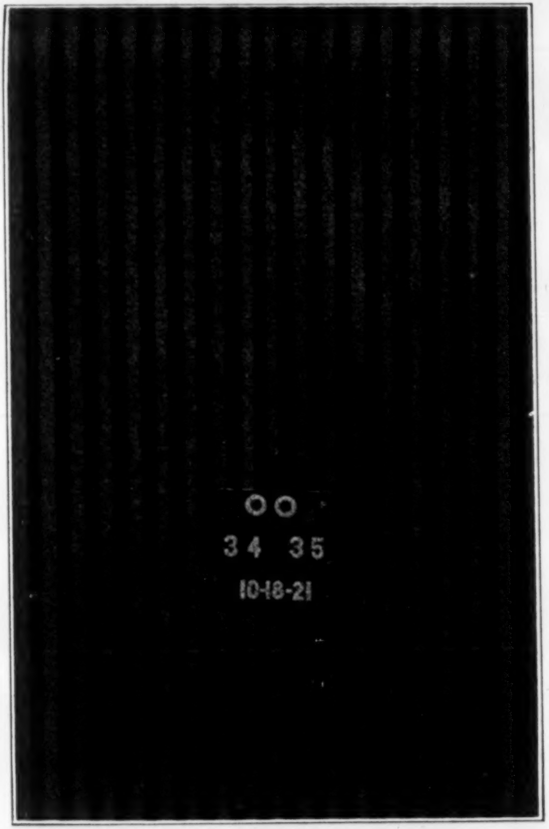


FIG. 25.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
OO 34...	0.14	0.38	0.012	0.027	0.005	0.036	Trace
OO 35...	0.12	0.38	0.012	0.027	0.005	0.028	Trace

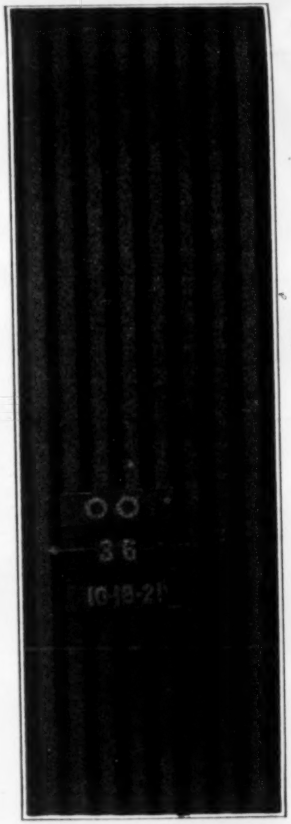


FIG. 26.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
OO 36...	0.11	0.38	0.010	0.026	0.005	0.032	Trace

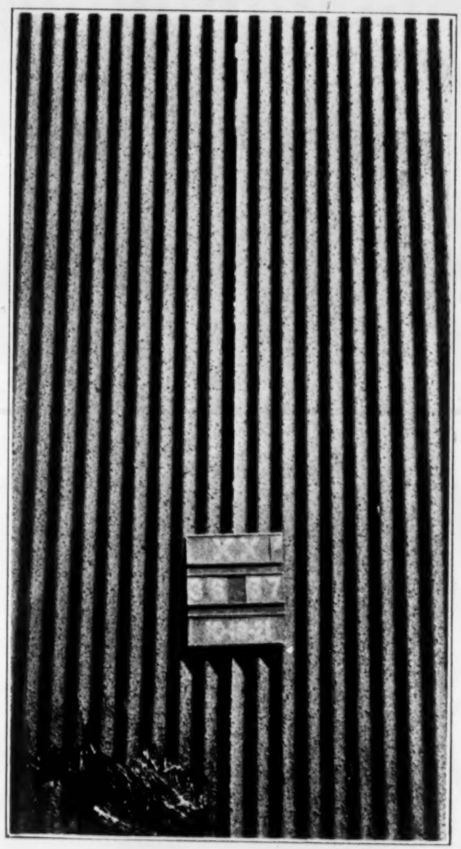


FIG. 27.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES B.
INLAND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	No.
XX 36. .	0.02	0.07	0.006	0.032	Trace	0.03	None
XX 37. .	0.01	0.08	0.007	0.035	Trace	0.03	None

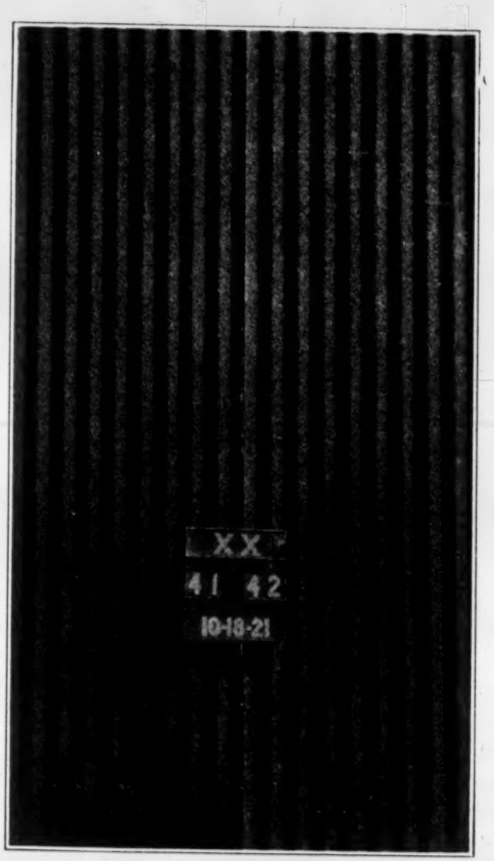


FIG. 28.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER PURE IRON—SERIES B.
INLAND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
XX 41. .	0.015	0.06	0.006	0.041	Trace	0.025	None
XX 42. .	0.02	0.08	0.006	0.031	Trace	0.025	None

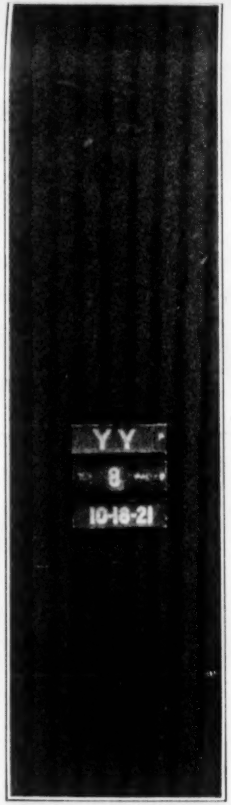


FIG. 29.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER WROUGHT IRON—SERIES B
YOUNGSTOWN SHEET AND TUBE CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
YY 8 . . .	0.03	0.05	0.130	0.018	0.20	0.024	. . . .

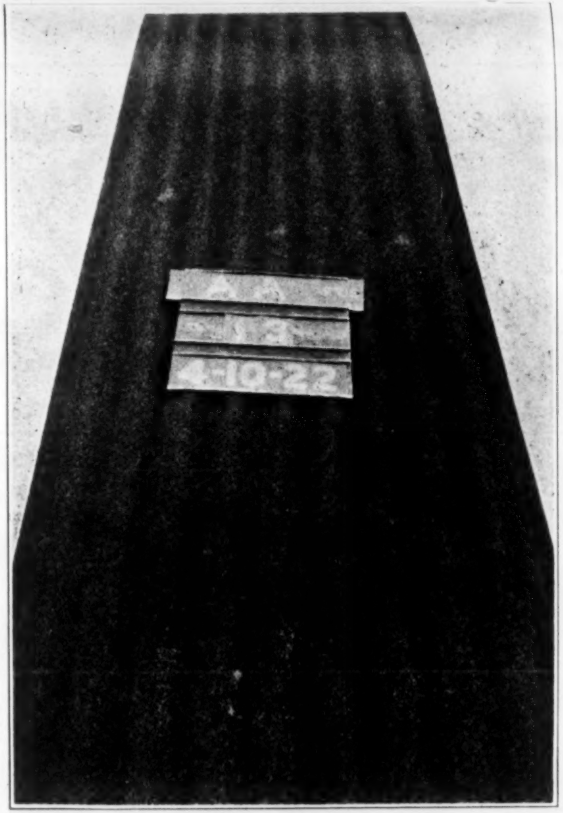


FIG. 30.—FORT SHERIDAN TESTS.
No. 16 GAGE BESSEMER STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
AA 13. . .	0.014	0.42	0.087	0.041	0.004	0.012	. . . .

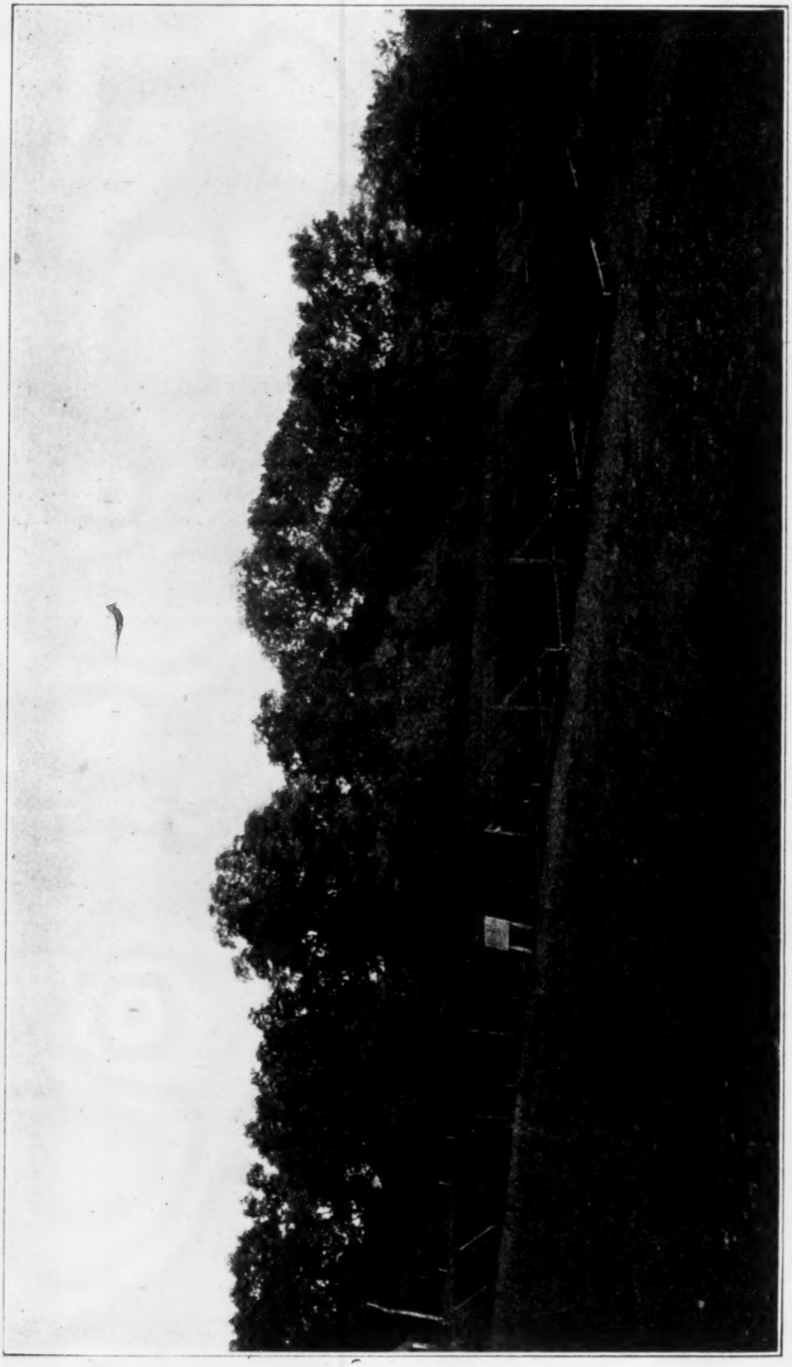


FIG. 31.—GENERAL VIEW OF ANNAPOLIS TEST RACK. October 19, 1921.

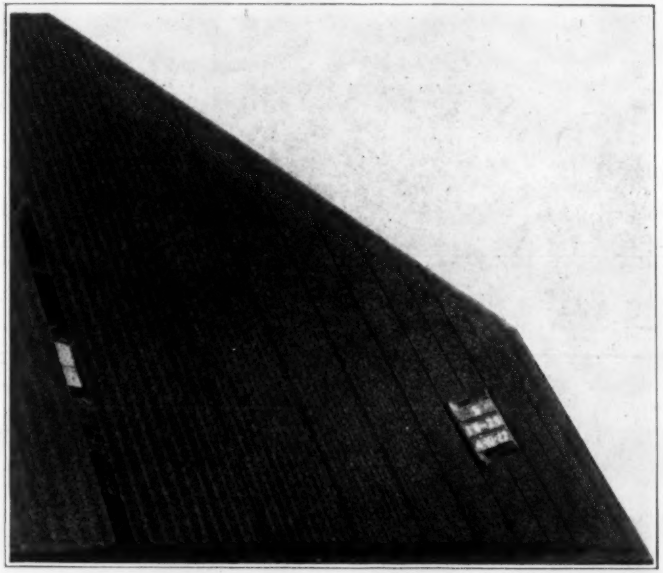


FIG. 32.—FORT SHERIDAN TESTS.
No. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
AMERICAN ROLLING MILL CO.

Sheets.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
S 18-28..							
Average....	0.02	0.023	0.006	0.022	0.004	0.022	None

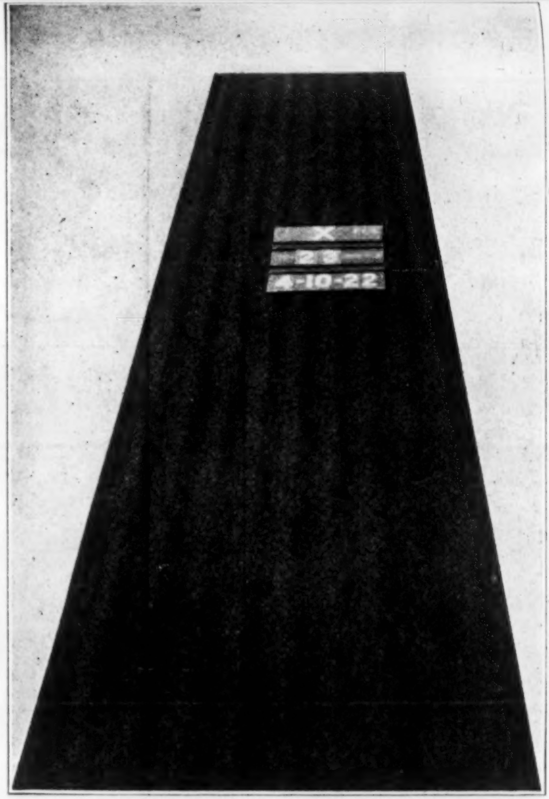


FIG. 33.—FORT SHERIDAN TESTS.
No. 22 GAGE LOW-COPPER PURE IRON—SERIES B.
INLAND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
X 23....	0.015	0.09	0.009	0.035	....	0.020	....

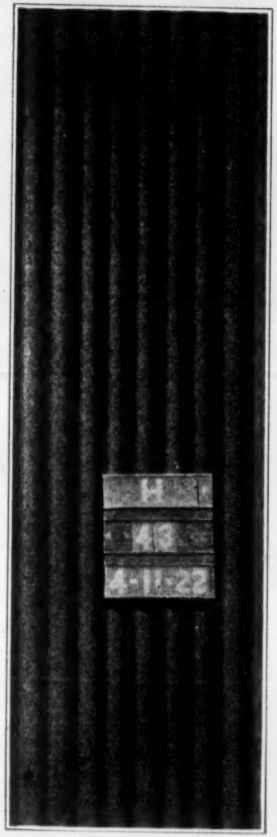


FIG. 34.—PITTSBURGH TESTS.
NO. 22 GAGE COPPER-BEARING BASIC OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
H 43....	0.09	0.44	0.060	0.029	....	0.25	None

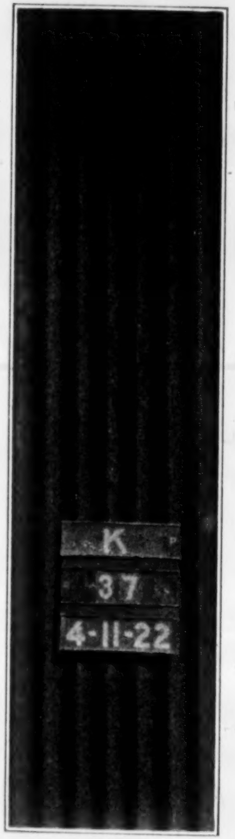


FIG. 35.—PITTSBURGH TESTS.
NO. 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 37....	0.11	0.49	0.107	0.050	....	0.25	....

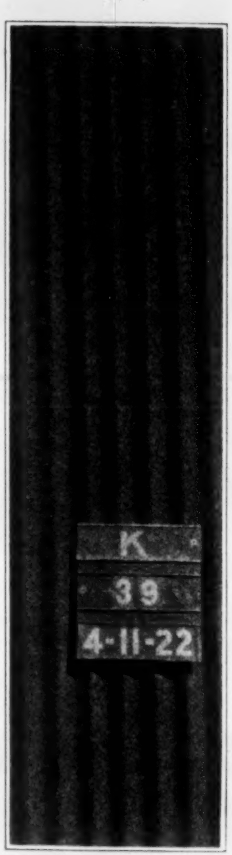


FIG. 36.—PITTSBURGH TESTS.
NO. 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 39....	0.10	045	0.0.93	0.053	....	0.25	....

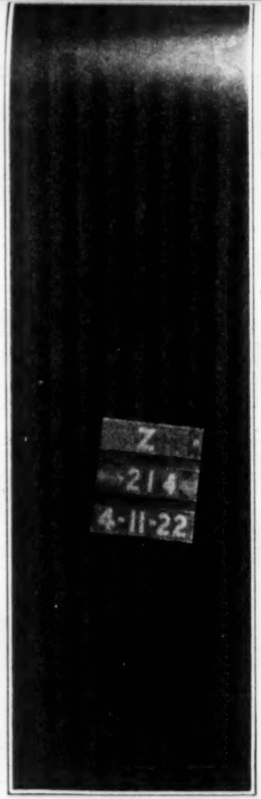


FIG. 37.—PITTSBURGH TESTS.
No. 22 GAGE BESSEMER STEEL (VARYING COPPER CONTENT)—SERIES B.
YOUNGSTOWN SHEET AND TUBE CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 214...	0.038	0.37	0.080	0.030	None	0.260	None

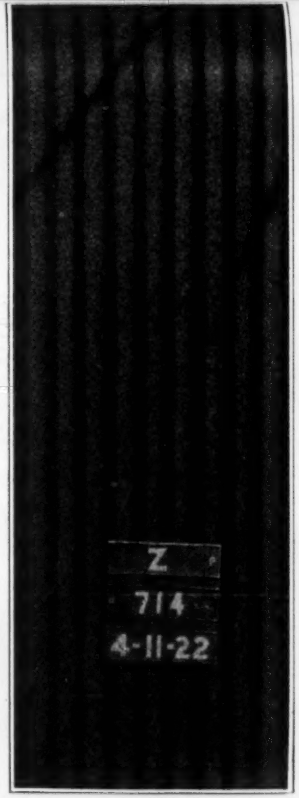


FIG. 38.—PITTSBURGH TESTS.
No. 22 GAGE OPEN-HEARTH STEEL (VARYING COPPER CONTENT)—SERIES B.
YOUNGSTOWN SHEET AND TUBE CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 714...	0.06	0.41	0.037	0.039	Trace	0.520	None

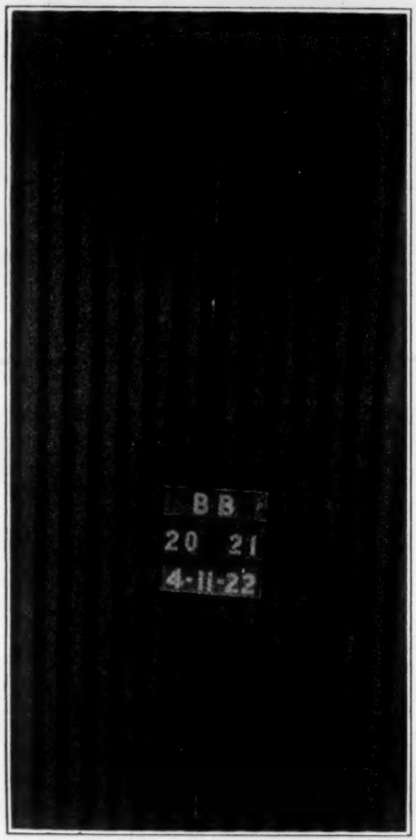


FIG. 39.—PITTSBURGH TESTS.
No. 16 GAGE OPEN-HEARTH STEEL—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	[Ni.]
BB 20...	0.092	0.495	0.015	0.037	0.004	0.046	....
BB 21...	0.094	0.486	0.016	0.029	0.003	0.042	....

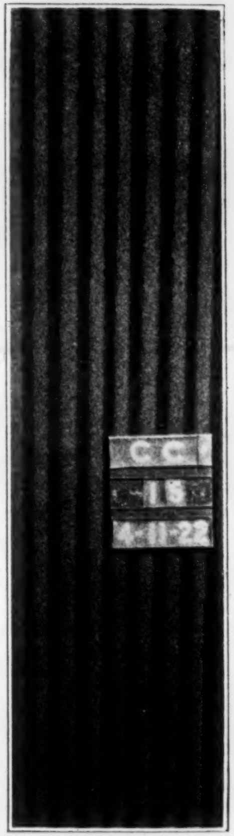


FIG. 40.—PITTSBURGH TESTS.
No. 16 GAGE COPPER-BEARING PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
CC 15...	0.01	0.023	0.001	0.034	0.002	0.061	....

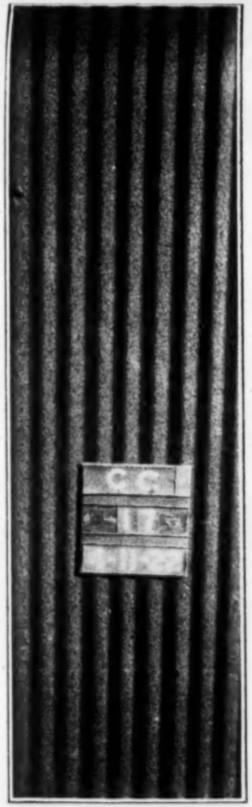


FIG. 41.—PITTSBURGH TESTS.

No. 16 GAGE COPPER-BEARING PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
CC 17...	0.01	0.019	0.001	0.040	0.002	0.069	....

FIG. 42.—PITTSBURGH TESTS.

No. 16 GAGE LOW-COPPER PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 8...	0.03	0.03	0.004	0.034	....	0.034	....
DD 9...	0.032	0.022	0.004	0.034	....	0.030	....

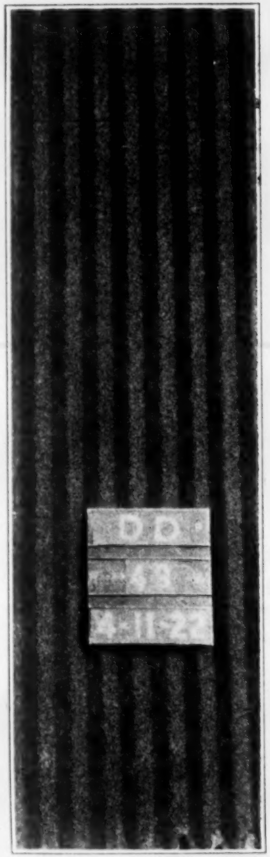


FIG. 43.—PITTSBURGH TESTS.
No. 16 GAGE LOW-COPPER, PURE IRON—SERIES A.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 49	0.03	0.02	0.003	0.020	...	0.028	...

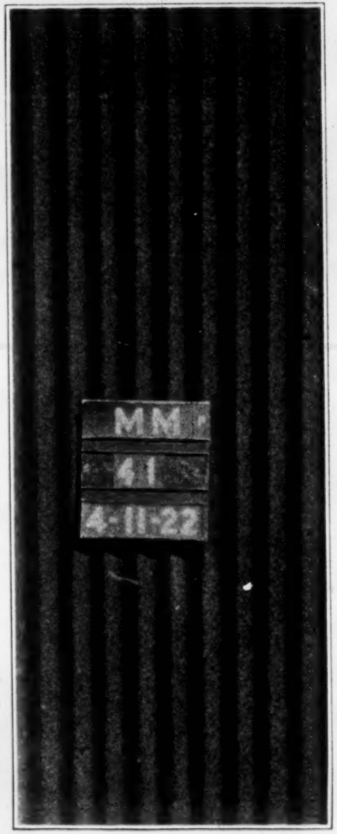


FIG. 44.—PITTSBURGH TESTS.
No. 16 GAGE OPEN-HEARTH STEEL—SERIES B.
ALAN WOOD IRON AND STEEL CO.

Sheet.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 41..	0.115	0.42	0.012	0.032	0.005	0.08	None

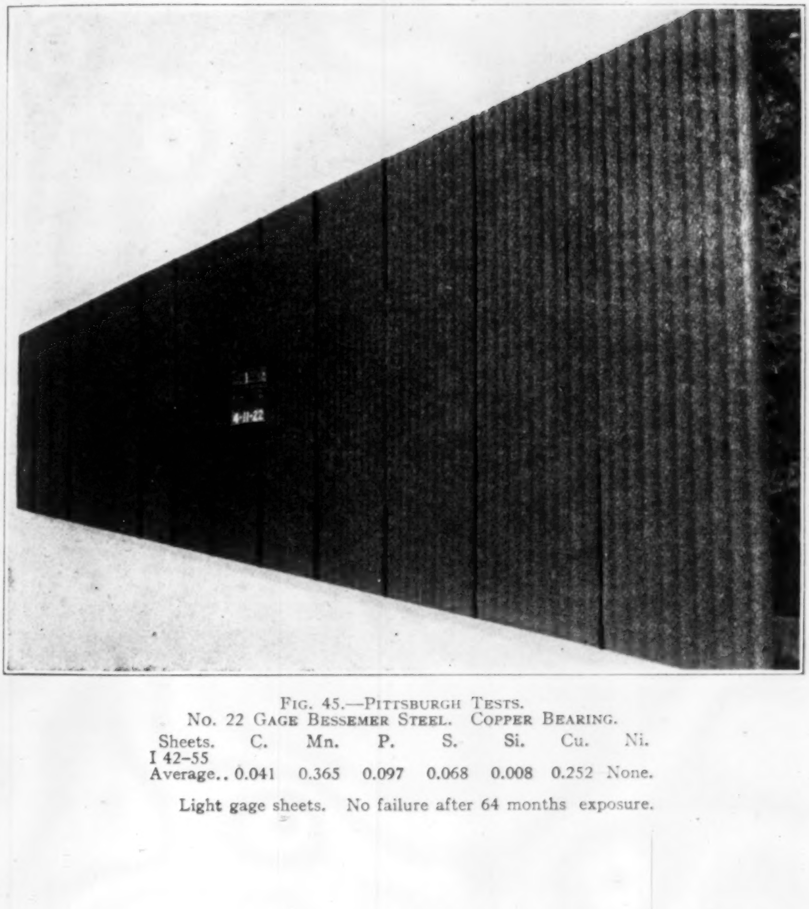


FIG. 45.—PITTSBURGH TESTS.
No. 22 GAGE BESSEMER STEEL. COPPER BEARING.

Sheets.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
I 42–55							
Average..	0.041	0.365	0.097	0.068	0.008	0.252	None.

Light gage sheets. No failure after 64 months exposure.

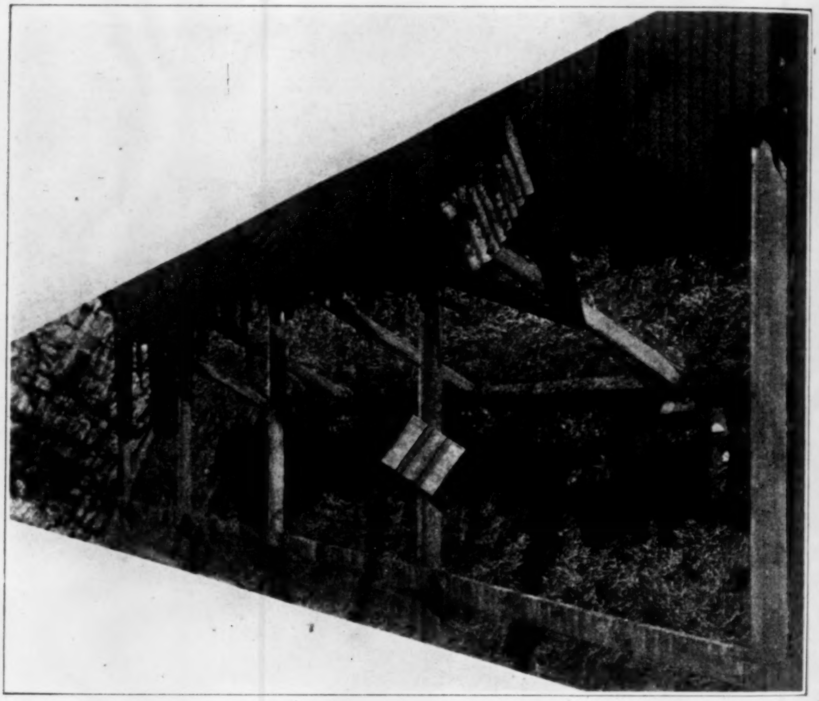


FIG. 46.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL. NON-COPPER BEARING.

Sheets.	C.	Mn.	P.	S.	Si.	Cu.	Ni.
AA 25–30 50–55							
Average..	0.043	0.419	0.083	0.042	0.004	0.012	None.

Heavy gage sheets. Failed after 28 months' exposure.

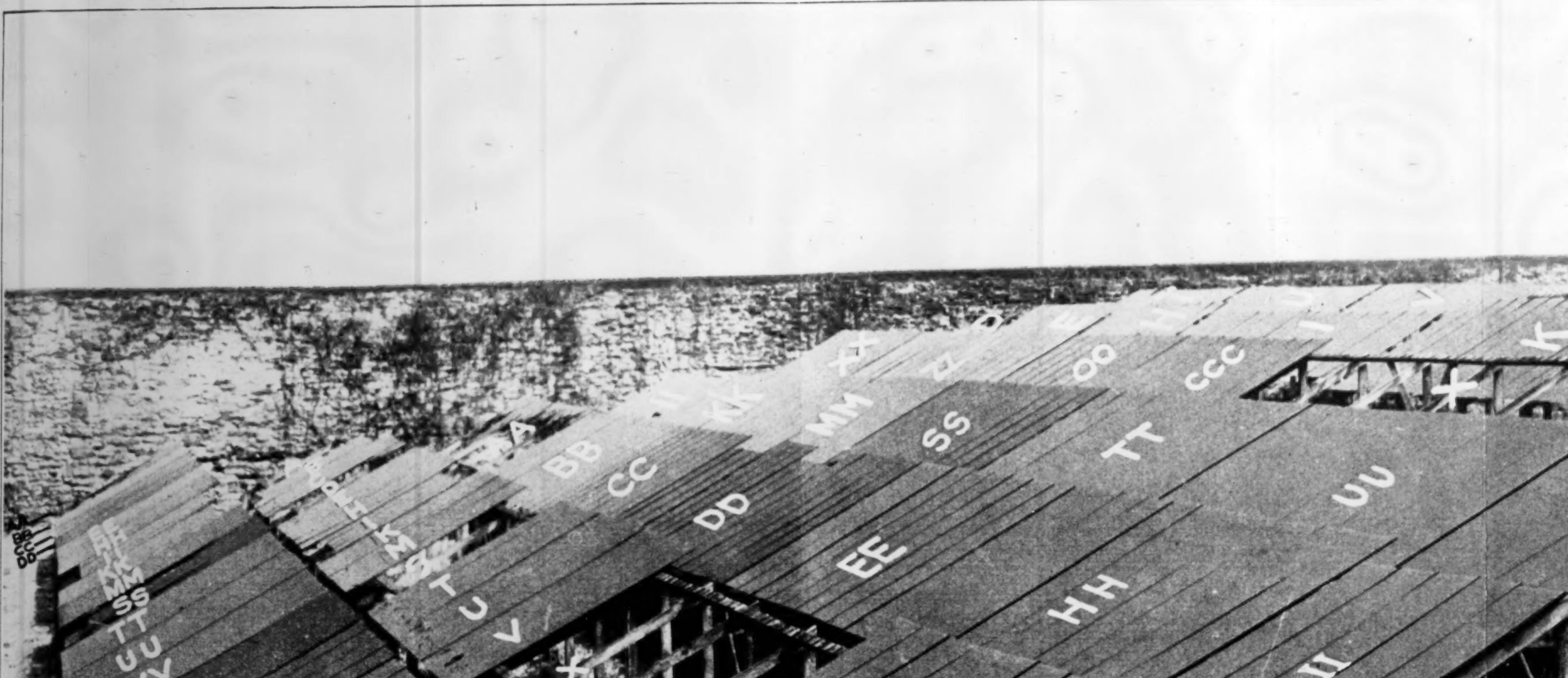
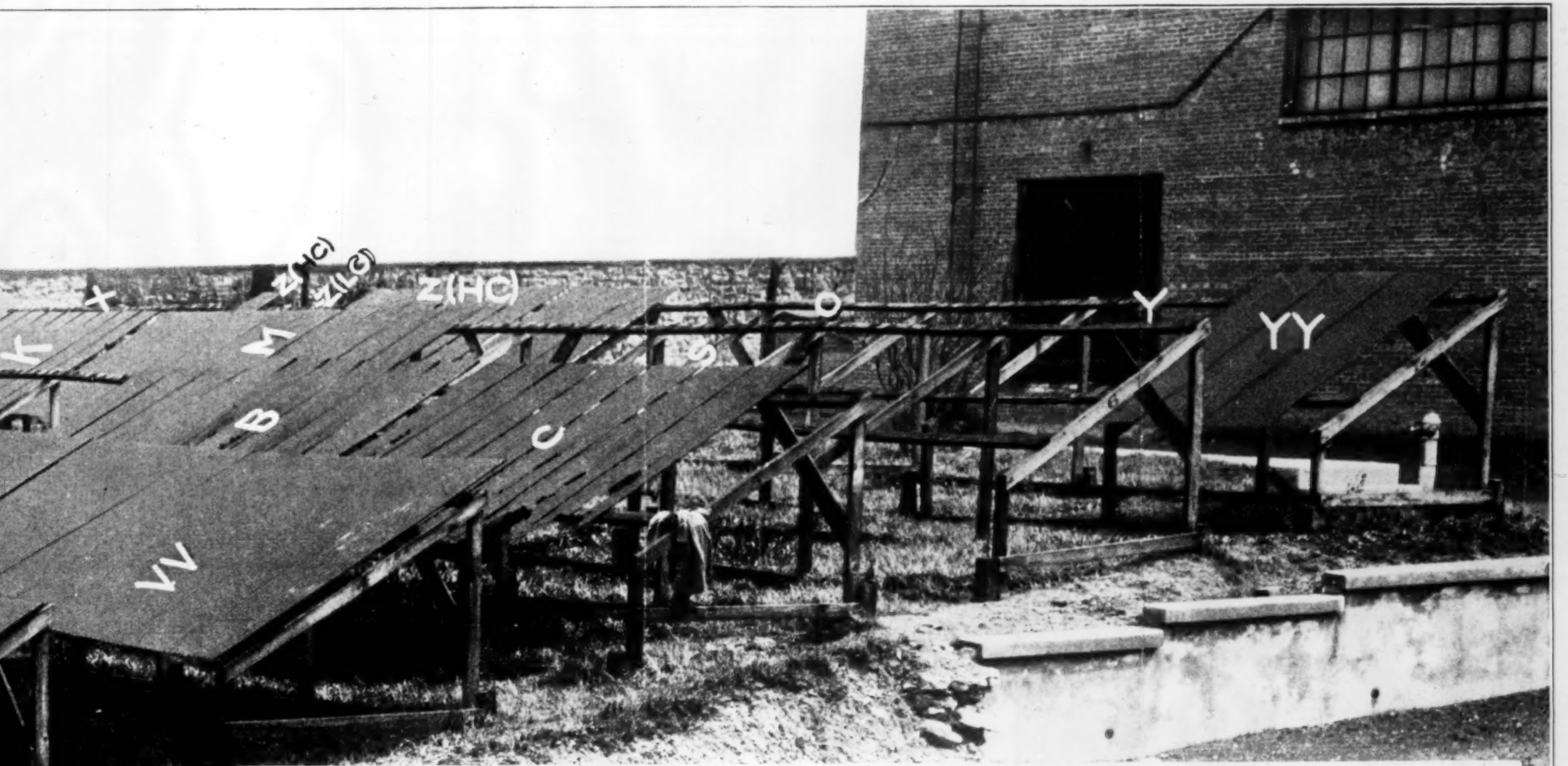

AA
BB
CC
DD
EE
HH
II
KK
MM
XX
OO
CCC
SS
TT
UU
VV
T
U
V
X
O
Z(LC)
Z(HC)
ZZ(LC)
ZZ(HC)
K

Fig. 47.—Pittsburgh Tests Sheets Exposed Dece

Plate III.
Proc. Am. Soc. Test. Mats.
Vol. 22, Part I.
Report of Committee A-5:
On Corrosion Tests.



No. 16 Gage.	
HH	Copper-bearing Basic Open-Hearth Steel, Series A.
ZZ(HC)	Copper-bearing Steel, Series B, Youngstown Sheet and Tube Co. (ZZ(HC) indicates copper 0.153 to 0.586 per cent.)
II	Copper-bearing Bessemer Steel, Series A.
TT	Copper-bearing Steel, Series B, Newport Rolling Mill Co.
KK	Copper-bearing Acid Open-hearth Steel, Series A.
UU	Copper-bearing Pure Iron, Series B, Allegheny Steel Co.
CCC	Copper-bearing Pure Iron, Series A.
EE	Puddled Iron, Series A.
BB	Open-hearth Steel, Series A.
VV	Copper-bearing Pure Iron, Series B, Whitaker-Glessner Co.
YY	Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co. (Sheets exposed June 2, 1917.)
CC	Copper-bearing Pure Iron, Series A.
MM	Open-hearth Steel, Series B, Alan Wood Iron and Steel Co.
DD	Low-Copper Pure Iron, Series A.
OO	Low-Copper Open-hearth Steel, Series A.
ZZ(LC)	Low-Copper Steel, Series B, Youngstown Sheet and Tube Co. (ZZ(LC) indicates copper 0.034 per cent or under.)
XX	Low-Copper Pure Iron, Series B, Inland Steel Co.
SS	Low-Copper Pure Iron, Series B, American Rolling Mill Co.
AA	Bessemer Steel, Series A.

No. 22 Gage.	
Z(HC)	Copper-bearing Steel, Series B, Youngstown Sheet and Tube Co. (Z(HC) indicates copper 0.126 to 0.712 per cent.)
I	Copper-bearing Bessemer Steel, Series A.
H	Copper-bearing Basic Open-hearth Steel, Series A.
K	Copper-bearing Acid Open-hearth Steel, Series A.
B	Open-hearth Steel, Series A.
T	Copper-bearing Steel, Series B, Newport Rolling Mill Co.
U	Copper-bearing Pure Iron, Series B, Allegheny Steel Co.
V	Copper-bearing Pure Iron, Series B, Whitaker-Glessner Co.
Y	Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co. (Sheets exposed June 2, 1917.)
C	Coper-bearing Pure Iron, Series A
M	Open-hearth Steel, Series B, Alan Wood Iron and Steel Co.
E	Puddled Iron, Series A.
D	Low-Copper Pure Iron, Series A.
Z(LC)	Low-Copper Steel, Series B, Youngstown Sheet and Tube Co. (Z(LC) indicates copper 0.019 per cent or under.)
S	Low-Copper Pure Iron, Series B, American Rolling Mill Co.
X	Low-Copper Pure Iron, Series B, Inland Steel Co.
A	Bessemer Steel, Series A.
O	Low-Copper, Open-hearth Steel, Series A.

December 12, 1916. Photographed April 11, 1922.

REPORT OF SUB-COMMITTEE V ON TOTAL IMMERSION TESTS.

Sub-Committee V on Total Immersion Tests reports that there have been no failures in the test racks at either the Bureau of Standards at Washington, D. C., or at the Naval Experiment Station at Annapolis.

The No. 22 gage specimens are getting very thin, and it looks as if there would be some failures before long. The test racks at both stations are being carefully watched.

Respectfully submitted on behalf of the sub-committee,

William A. Cooper,
Chairman.

REPORT OF COMMITTEE A-7

ON

MALLEABLE CASTINGS.

Progress in the betterment of the iron used in malleable castings is recorded by the specifications of this Society. Specifications were originated in 1904 and no changes were made for eleven years. In 1915 the first revision was made. Four years later, in 1919, the requirements were materially increased. The tensile strength requirement was raised from 38,000 lb. per sq. in. to 45,000 lb. per sq. in. and the requirement for elongation was raised from 5 per cent in 2 in. to 7.5 per cent in 2 in. Malleable foundries have now been working to these specifications for three years and at a meeting of Committee A-7, held in Cleveland on April 3, it was decided that malleable iron could be made commercially with still better physical properties. In reference to the question of rejection according to Section 6 (*b*) of the present specifications, which would cause the rejection of an oven of castings if the test specimens representing that oven failed, perhaps on account of flaws and therefore not really representative of the castings, the committee decided to recommend a change so that retests could be made at the discretion of the inspector.

Your committee, therefore, proposes the following revisions in the Standard Specifications for Malleable Castings (A 47 – 19),[1] for publication as tentative:

Section 3.—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

"The tension test specimens specified in Section 5 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	[45 000]	*50 000*
Elongation in 2 in., per cent	[7.5]	*10.0*"

Section 6 (b).—Add a sentence to read as follows:

"In case one of the retest specimens contains a flaw which results in the failure of the bar to meet the specifications, at the discretion of the inspector additional test specimens from the same oven may be tested, or test specimens may be cut from castings."

---

[1] 1921 Book of A.S.T.M. Standards.

It is further recommended that the standard test specimen be modified to conform to the dimensions shown in Fig. 1. As may be noted, this changes the total length of the test specimen from 12 in. to 7½ in. and the gage length from 4 in. to 2 in.

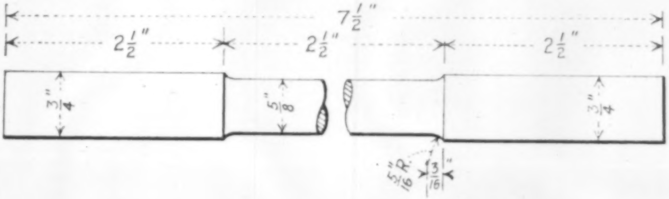


FIG. 1.

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 16 have voted affirmatively, one negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. E. DILLER,
Chairman.

ENRIQUE TOUCEDA,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Standard Specifications for Malleable Castings referred to in this report were accepted for publication as tentative and appear on page 984.

REPORT OF COMMITTEE B-1

ON

COPPER WIRE.

Two matters of importance with respect to copper wire have come up during the past year. First, the work on insulated wires and cables has been placed upon a businesslike basis through the organization of a very representative and comprehensive committee under the Rules of Procedure of the American Engineering Standards Committee. Practically all of the technical organizations which are interested in the standardization of insulated copper conductors are cooperating in the work and our society is one of a number of joint sponsors. We are represented on the committee by members selected from Committees B-1 on Copper Wire, D-9 on Electrical Insulating Materials and D-11 on Rubber Products.

Second, the American Electric Railway Association has suggested renewal of cooperative efforts to arrive at specifications for copper trolley wire which will be acceptable both to that association and to the American Society for Testing Materials. This suggestion was accepted by our Executive Committee who appointed a special committee from among the members of Committee B-1 to meet with a similar committee representing the A.E.R.A. Several meetings of the Joint Committee have been held and the prospects of a successful issue are excellent.

Committee B-1 has realized that the conditions of service under which trolley wire operates are more severe than those for other types of conductor, and that special requirements for trolley wire may well be warranted. Since agreement with the A.E.R.A. on specifications for trolley wire now seems probable, Committee B-1 has agreed that these specifications should be separate from the general Specifications for Hard-Drawn Copper Wire (B 1 – 15).[1] To pave the way for the issue of specifications for copper trolley wire when and if they are agreed upon, Committee B-1 recommends that all requirements specifically covering trolley wire only be removed from Specifications B 1 – 15, and that these specifications, with the requirements for trolley wire removed, continue as the standard specifications for round, hard-drawn copper wire.

---

[1] 1921 Book of A.S.T.M. Standards.

The matter to be removed from Specifications B 1 – 15 is scheduled as follows:

Section 2. Omit "grooved trolley wire and figure-eight trolley wire, as hereinafter described."

Section 3 (*a*). Omit "in all shapes."

Section 4 (*a*). Omit "standard packages of grooved trolley wire shall be shipments upon reels holding about 2500 lb. each."

Section 10. Omit entire section.

Section 11 (*a*) and (*b*). Omit entire section.

Section 12. Omit entire section.

Section 13. Omit entire section.

Section 14. Omit entire section.

Section 15. Omit entire section.

It is the hope of Committee B-1 that next year we may report specifications for copper trolley wire which will be offered for approval jointly by the A.E.R.A. and the A.S.T.M.

The members of the committee voted unanimously to recommend the removal of the special requirements for trolley wire from Specifications B 1–15 and the continuation of these specifications as standard for hard-drawn copper wire.

The committee desires to give notice at this time that at the next annual meeting it will ask permission to remove all requirements specifically covering trolley wire from Specifications B 1–15 and have them remain the Standard Specifications for Hard-Drawn Copper Wire. This is in order that the Standard Specifications for Hard-Drawn Copper Wire which are now well established may not have to become tentative because of the removal of the trolley wire requirements.

This report has been submitted to letter ballot of the committee, which consists of ten members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

EDITORIAL NOTE.

The proposed revisions of the Standard Specifications for Hard-Drawn Copper Wire referred to in this report were accepted for publication as tentative and appear on page 986.

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS.

The work of Committee B-2 accomplished during the past year, if measured in terms of new tentative standards being submitted, consists in the preparation of three tentative specifications: namely, Specifications for Brass Pipe, Standard Sizes; for Copper Pipe, Standard Sizes; and for Seamless Admiralty Condenser Tubes and Ferrule Stock, and of two tentative methods of chemical analysis: namely, for Brass Ingots and Sand Castings; and for Bronze Bearing Metal. Two tentative specifications are being recommended for advancement to standard: namely, the Tentative Specifications for Nickel; and for Brass Ingot Metal, Graded and Ungraded, for Sand Castings.

The work can best be summarized by giving the reports of the various sub-committees which were accepted at the last meeting of the committee held on April 10.

SUB-COMMITTEE I ON PURE METALS IN INGOT FORM.

The sub-committee recommends the following revisions in the Tentative Specifications for Pig Lead (B 29 – 20 T):[1]

Section 4.—Change the requirements for zinc from 0.001 per cent to 0.0015 per cent and the requirements for lead (by difference) from 99.9335 per cent to 99.9330 per cent.

Insert a footnote to read as follows:

"The maximum limits for bismuth, copper and silver have been given, but it is not expected that any delivery will contain the maximum of all three."

Section 5.—Change from its present form: namely,

"Chemical Lead (Grade II) shall conform to the following requirements as to chemical composition.[a]

Copper	0.04 – 0.10	per cent
Bismuth	not over 0.005	"
Total Impurities other than Copper	" " 0.05	" "

[a] This composition represents present requirements in the United States.

to read as follows:

"Chemical Lead (Grade II) is a designation that has been used for many years in the trade to describe the undesilverized lead produced from Southeastern Missouri ores. This lead contains from 0.04 to 0.08 per cent of copper, from 0.005 to 0.015 per cent (1½ to 4½ oz. per ton) of silver and carries less than 0.005 per cent of bismuth."

---

[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 554 (1920).

Section 6. (*a*).—Change the requirements for bismuth from 0.35 per cent to 0.25 per cent and the requirements for lead (by difference) from 99.6265 per cent to 99.7265 per cent.

The sub-committee considered the matter of specifications for lead pipe, brought to its attention because of questions brought up by the American Water Works Association. It was decided, however, that lead pipe was not within the province of this sub-committee, since lead pipe ordinarily is made from chemical lead. The question of specifications for lead for cable sheathing was also considered but since such sheathings are usually made from alloys, manufacturers may select the proper grade of pig lead from those specified in the Tentative Specifications for Pig Lead, and it is felt that there is no need for separate specifications.

Committee B-2 recommends that the revisions in the Specifications for Pig Lead as given above be approved, and the tentative specifications, as revised, be continued as tentative for another year. The committee further recommends that the Tentative Specifications for Nickel (B 39 - 21 T)[1] be adopted as standard, with the inclusion of a note reading as follows:

> "The requirement for carbon in electrolytic nickel covers both contained and mechanically attached carbon from the starting sheet, and it should be recognized that while lower values can be obtained by separating the cathode sheets from the starting sheet and pickling before drilling, this method of taking the sample is outside of these specifications."

SUB-COMMITTEE II ON WROUGHT METALS AND ALLOYS.

Three tentative specifications were prepared by this sub-committee and are recommended by Committee B-2 for acceptance by the Society for publication as tentative, as follows: For Brass Pipe, Standard Sizes; for Copper Pipe, Standard Sizes; and for Seamless Admiralty Condenser Tubes and Ferrule Stock. These tentative specifications are appended hereto.[2]

SUB-COMMITTEE III ON SAND-CAST METALS AND ALLOYS.

This sub-committee recommends that the following revisions be made in the Tentative Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings (B 30 - 21 T):[3]

Section 2.—Transfer the second sentence reading as follows from Section 2 making it a part of Section 3:

> "Individual ingots of any lot shall not show an extreme variation between the high and low copper percentages of more than 2.5 per cent and between

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 495 (1921).

[2] See pp. 653–663.—ED.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 491 (1921).

the high and low percentages of the other main constituents, except zinc, of more than 1.5 per cent."

Section 4.—Change the table appearing in Section 4 to read as follows, to include requirements for phosphorus, and grouping under the heading of "Impurities" the elements iron, antimony, aluminum, sulfur and phosphorus:

Alloy, Grade No.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.	Impurities, maximum, per cent.				
					Iron.	Antimony.	Aluminum.	Sulfur.	Phosphorus.
1...........	87	8	2[a]	3	0.25	0.25	none	0.05	0.05
2...........	85	5	5	5	0.35	0.25	none	0.05	0.05
3...........	83	4	6	7	0.35	0.25	none	0.05	0.05
4...........	77	3	10	10	0.40	0.35	none	0.05	0.05
5...........	76	2	6	16	0.40	0.25	none	0.05	0.05
6...........	65	1[a]	2	33	0.50	0.20	none[1]	0.05	0.02
7...........	60	1½[a]	3	37	1.00	0.20	none[1]	0.05	0.02

[a] Maximum.

[1] See Appendix.

The committee recommends that the tentative specifications, as revised, be adopted as standard.

The question of a proper standard test bar for the different cast non-ferrous alloys has been discussed, and it was suggested that this topic was a suitable one for a symposium before the Society.

SUB-COMMITTEE IV ON WHITE METALS.

The work of investigating the physical properties of white metal bearing alloys with a view to revising the table of physical properties appearing as an appendix to the Tentative Specifications for White Metal Bearing Alloys (B 23 – 18 T) is reported in Appendix I to this report in a paper entitled "The Physical Properties of the A.S.T.M. Tentative Standard White Metal Bearing Alloys" by John R. Freeman, Jr., of the Bureau of Standards.

SUB-COMMITTEE V ON PLATES, TUBES, AND STAYBOLTS FOR LOCOMOTIVES.

The question of revising the elongation requirements in the Standard Specifications for Copper Plates for Locomotive Fireboxes (B 11 – 18) and the Standard Specifications for Copper Bars for Locomotive Staybolts (B 12 – 18) was referred to the sub-committee last year, but too late for any definite recommendations to be made at the last annual meeting of the Society. Since then, samples of copper for locomotive staybolts and of copper for locomotive fireboxes, both arsenical and non-arsenical, furnished by Messrs. Hendricks Bros., were tested by the American Brass Co., the Scovill Manufacturing Co., and the Bridgeport Brass Co. The results of these tests are as follows:

Material	Thickness or Diameter, in.	Tensile Strength, lb. per sq. in.	Elongation in 8 in., per cent.	Grade	Tested by
Fire Box Sheet............	$\frac{1}{2}$	32 600	37.6	Arsenical	Bridgeport Brass Co.
Fire Box Sheet............	$\frac{1}{2}$	30 400	37.6	Non-Arsenical	Bridgeport Brass Co.
Fire Box Sheet............	$\frac{1}{2}$	31 200	35.4	Arsenical	Scovill Mfg Co
Fire Box Sheet............	$\frac{1}{2}$	30 300	39.6	Non-Arsenical	American Brass Co.
Staybolt Rod............	1	32 200	48.3	Arsenical	Bridgeport Brass Co.
Staybolt Rod............	1	31 600	49.5	Non-Arsenical	Bridgeport Brass Co.
Staybolt Rod............	1	31 900	49.9	Arsenical	Scovill Mfg Co
Staybolt Rod[1]............	1	32 100	37.3	Non-Arsenical	American Brass Co.

[1] This sample was turned to $\frac{3}{4}$-in. diameter before testing.

These results indicate that the change that had been suggested, and which prompted the investigation: namely, that the elongation in 8 in. for firebox sheets be changed from 30 and 35 per cent for non-arsenical and arsenical copper, respectively, to 40 per cent, was not warranted, but that the suggested change in the elongation in 8 in. for staybolt copper from 30 and 35 per cent for non-arsenical and arsenical copper, respectively, to 45 per cent, was warranted provided the specimens were tested without machining. No change, however, is suggested at this time.

SUB-COMMITTEE VII ON METHODS OF CHEMICAL ANALYSES.

The principal work of the sub-committee has been the preparation of Tentative Methods of Chemical Analysis of Brass Ingots and Sand Castings, and Tentative Methods of Chemical Analysis of Bronze Bearing Metal, for use in conjunction with the Standard Specifications for Bronze Bearing Metal in Ingot Form (B 31 – 21) and the Tentative Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings (B 30 – 21 T). The methods are based upon those submitted to Sub-Committee III by L. P. Webert and W. M. Corse, and subsequently submitted through N. K. B. Patch to Sub-Committee VII. Copies of methods, as used by other members of Sub-Committee III, had also been transmitted to Sub-Committee VII, and in connection with consideration of these, an outline of methods was drawn up by G. E. F. Lundell. The methods herewith submitted[1] comprise parts of the latter method as revised in accordance with suggestions made by Alden Merrill and the members of Sub-Committee VII present at the meeting of April 10. The sub-committee has considered methods of sampling, and it requests Sub-Committee III to revise the detailed instructions appearing in the Standard Specifications for Bronze Bearing Metal in Ingot Form (B 31 – 21) so as to insure a representative sample being obtained, in view of the probable separation in the saw cuttings of brittle components of the alloy, due to its heterogeneous structure. A note by G. E. F. Lundell, illustrating the importance of this subject, appears in Appendix II to this report.

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[1] See pp. 664–687.—ED.

During the year, a number of the standard methods of chemical analysis of non-ferrous metals have been recommended to the American Engineering Standards Committee for acceptance as American Standard. Three have already been accepted as Tentative American Standard: namely, The Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19), the Standard Methods of Chemical Analysis of Gun Metal (B 28 – 19) and the Standard Methods of Battery Assay of Copper (B 34 – 20). The Standard Methods of Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (B 18 – 21) are now before the Standards Committee for consideration. The sub-committee has been represented on the National Committee for Standardization of Zinc, by Messrs. Price and Lundell, and methods are to be considered for the determination of other elements in spelter, namely, aluminum, tin, and bismuth. Sub-Committee VII will cooperate with this committee in revising the methods of chemical analysis of zinc.

SUB-COMMITTEE VIII ON ALUMINUM ALLOYS, CAST AND WROUGHT.

This sub-committee recommends that the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (B 24 – 20 T)[1] be revised as follows:

Section 2.—Change from its present form: namely,

> "The presence in any of the above grades of manganese, magnesium, zinc, calcium or similar metals commonly used in the light alloys, or of copper in excess of 0.1 per cent is not admissible, and such ingot cannot be classed as Virgin Aluminum under these specifications. Iron, silicon, and copper (not in excess of 0.1 per cent) are allowable impurities."

to read as follows:

> "The presence in any of the above grades of manganese, magnesium, zinc, calcium or similar metals commonly used in the light alloys, is not admissible and such ingot cannot be classed as Virgin Aluminum under these specifications. Copper is an allowable impurity up to a maximum of 0.1 per cent in the 99.5 grade; 0.25 per cent in the 99.0 grade; and 0.45 per cent in the 98.0 grade. Iron and silicon are also allowable impurities. The sum total of the impurities, however, shall not exceed 0.5 per cent in the 99.5 grade, 1.0 per cent in the 99.0 grade, nor 2.0 per cent in the 98.0 grade."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 543 (1920).

The 99.5 grade is being continued at the present time until the subject has been carefully considered by the Aircraft Bureau and their recommendations have been received. The committee recommends that the tentative specifications, as amended, be continued as tentative.

The question as to whether large ingots of aluminum, cast directly from the reduction pots and showing a gray color and slag spots on the top surface, constitute delivery of 99.0 aluminum was considered, but it was felt that this is a matter to be left to agreement between the buyer and seller and not a subject that should be introduced into the specifications.

SUB-COMMITTEE IX ON NOMENCLATURE OF METALS AND ALLOYS.

Since submitting the report of progress contained in the Report of Committee B-2 for 1921, the sub-committee has not received any further comments from any of the foreign or domestic societies in reference to its report as contained in the Report of Committee B-2 for 1920. In view of this fact and taking into consideration that the sub-committee's report for 1920 contains only a brief outline of a proposed nomenclature of non-ferrous alloys, the sub-committee believes that the sub-committee's report for 1920 should remain open for another year, during which time such additions to the nomenclature as may be deemed advisable will be made.

Two years ago, a very extensive list of alloys was compiled from various sources by William Campbell, but because of high printing cost, it could not be published at that time. The committee believes that the publication of this list when brought up to date will be valuable information and therefore recommends that this list be published, if feasible.[1]

SUB-COMMITTEE X ON METHODS OF TESTING.

The question of revising the compression tests for bronze, etc., in order to make them conform to those adopted as standard for iron and steel, has been under discussion. The matter is being taken up with Committee E-1 on Methods of Testing. The question of proper standards for test bars for the various non-ferrous alloys, is one of great importance and it is felt that this matter should be discussed by the Society at large before any attempts are made to formulate definite recommendations.

The Advisory Committee of Committee B-2 proposed that there should be three stated meetings a year: one on or about October 15 in Philadelphia, and one in April in New York City; the final meeting should be held at the annual meeting as it has been in previous years. The committee likewise advised that a rule be made, requiring the chairmen of sub-committees to submit programs for the year's work at the October meeting, and that the chairmen be required to have their sub-committee reports ready in time for action at the April meeting. These recommendations were approved.

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[1] The list of alloys referred to has been accepted for publication and appears as Appendix III to this report.—ED.

The analysis of the letter ballot of the committee is as follows:

Item.	Affirmative.	Negative.	Not Voting.
I. PROPOSED REVISIONS IN TENTATIVE STANDARDS.			
1. For Pig Lead (B 29 - 19 T)	40	0	61
2. For Aluminum Ingots for Remelting and for Rolling (B 24 - 20 T)	28	0	73
II. PROPOSED NEW TENTATIVE STANDARDS.			
3. Brass Pipe, Standard Sizes	24	0	77
4. Copper Pipe, Standard Sizes	27	0	74
5. Seamless Admiralty Condenser Tubes and Ferrule Stock	26	0	75
6. Methods of Chemical Analysis of Bronze Bearing Metals	35	0	66
7. Methods of Chemical Analysis of Brass Ingot Metals	35	0	66
III. TENTATIVE STANDARDS TO BE ADOPTED AS STANDARD.			
8. For Brass Ingot Metal, Graded and Ungraded, for Sand Castings (B 30 - 21 T)	30	0	71
9. For Nickel (B 39 - 21 T)	28	1	72

This report has been submitted to letter ballot of the committee, which consists of 101 members, of whom 47 have voted affirmatively, none negatively, and 54 have refrained from voting.

Respectfully submitted on behalf of the committee,

WILLIAM CAMPBELL,
Chairman.

P. D. MERICA,
Secretary.

EDITORIAL NOTE.

The Tentative Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings and the Tentative Specifications for Nickel, both amended as indicated in this report were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1922.

The proposed revisions of the Tentative Specifications for Pig Lead and of the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling referred to in this report were accepted. The specifications as thus revised appear on pages 648 and 646, respectively.

The three proposed Tentative Specifications for Brass Pipe, Standard Sizes; for Copper Pipe, Standard Sizes; and for Seamless Admiralty Condenser Tubes and Ferrule Stock, and the two proposed Tentative Methods of Chemical Analysis of Bronze Bearing Metal and of Chemical Analysis of Brass Ingots and Sand Castings referred to in this report were accepted for publication as tentative and appear on pages 653–687.

For a discussion of this report, see page 243.

APPENDIX I.

THE PHYSICAL PROPERTIES OF THE A.S.T.M. TENTATIVE STANDARD WHITE METAL BEARING ALLOYS.

By John R. Freeman, Jr.[1]

Introduction.

The Bureau of Standards was requested by Committee B-2 on Non-Ferrous Metals and Alloys of the American Society for Testing Materials to determine the physical properties of the twelve white metal bearing alloys which have been adopted tentatively as standards by the Society and to revise the table of physical properties given in the appendix to the specifications.[2]

Table I.—Compositions of Tentative Standard Alloys of A.S.T.M.

Alloy No.	Tin, per cent.	Antimony, per cent.	Lead, per cent.	Copper, per cent.	Iron, maximum, per cent.	Arsenic, maximum, per cent.	Zinc, per cent.	Aluminum, per cent.
1	91	$4\frac{1}{2}$	0.35[a]	$4\frac{1}{2}$	0.08	0.10	None	None
2	89	$7\frac{1}{2}$	0.35[a]	$3\frac{1}{2}$	0.08	0.10	"	"
3	$83\frac{1}{3}$	$8\frac{1}{3}$	0.35[a]	$8\frac{1}{3}$	0.08	0.10	"	"
4	75	12	10	3	0.08	0.15	"	"
5	65	15	18	2	0.08	0.15	"	"
6	20	15	$63\frac{1}{2}$	$1\frac{1}{2}$	0.08	0.15	"	"
7	10	15	75	0.50[a]	....	0.20	"	"
8	5	15	80	0.50[a]	....	0.20	"	"
9	5	10	85	0.50[a]	....	0.20	"	"
10	2	15	83	0.50[a]	....	0.20	"	"
11	..	15	85	0.50[a]	....	0.25	"	"
12	..	10	90	0.50[a]	....	0.25	"	"

[a] Maximum

The properties of the alloys to be determined were the yield point, ultimate strength and Brinell hardness at normal temperatures and at 100° C. using the test methods developed at the Bureau of Standards and described in *Technologic Paper No. 188* of the Bureau of Standards.[3]

The compositions of the twelve A.S.T.M. alloys adopted tentatively as standard are given in Table I.

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[1] Associate Physicist, U. S. Bureau of Standards, Washington, D. C.

[2] Tentative Specifications for White Metal Bearing Alloys (B 23 – 18 T), *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 538 (1920).

[3] Also *Journal*, Society of Automotive Engineers, February, 1921.

Three complete series of the twelve alloys were prepared and tested. One of these series was prepared at the Bureau of Standards under careful laboratory control and the two other series were prepared by independent manufacturers to meet the specifications. These three series are distinguished throughout this paper by the following nomenclature; B. S., for the alloys prepared at the Bureau of Standards and A and B, respectively, for the two manufacturers.

The alloys prepared at the Bureau of Standards were made from pure Banka tin, high grade "Star" antimony and a commercially pure lead (99.94 per cent Pb).

The compositions of the alloys as shown by chemical analysis are given in Table II.

TABLE II.—COMPOSITION OF ALLOYS PREPARED AT THE BUREAU OF STANDARDS AND POURING TEMPERATURE USED FOR ALL ALLOYS TESTED.[1]

Alloy No.	Composition, per cent.								Pouring Temperature, deg. Cent.
	Copper.	Tin.	Antimony.	Lead.	Iron.	Arsenic.	Zinc.	Aluminum.	
1	4.56	90.9	4.52	None	0.05	....	Not detected	Not detected	440
2	3.1	89.2	7.4	0.03	0.03	0.11	..	..	430
3	8.3	83.4	8.2	0.03	0.02	0.04	..	..	490
4	3.0	75.0	11.6	10.2	0.06	0.12	..	..	360
5	2.0	65.5	14.1	18.2	0.07	0.12	..	..	350
6	1.5	19.8	14.6	63.7	0.11	0.09	..	..	335
7	0.11	10.0	14.5	75.0	0.14	0.10	..	..	330
8	0.14	5.2	14.9	79.4	0.14	0.08	..	..	330
9	0.06	5.0	9.9	84.6	0.17	0.06	..	..	325
10	0.12	2.05	15.7	82.0	0.08	0.07	..	..	330
11	0.19	0.09	14.8	84.7	0.17	0.09	..	..	330
12	0.12	0.11	9.9	89.4	0.14	0.05	..	..	335

[1] Mr. J. A. Scherrer of the Bureau of Standards made all chemical analyses.

APPARATUS AND TEST METHODS.

The apparatus (testing machine, extensometer, heating baths, etc.), used in all cases was the same in this work as that used in the previous investigation mentioned above and all results are calculated in the same manner, the yield point being taken from the stress-strain curve at a deformation of 0.125 per cent reduction of the gage length and the ultimate strength as the unit load necessary to produce a deformation of 25 per cent of the length of the specimen.

The compression test specimens were small cylinders $1\frac{1}{2}$ in. in length by $\frac{1}{2}$ in. in diameter machined from cylindrical chill castings 2 in. in length by $\frac{3}{4}$ in. in diameter.

The samples for Brinell testing were obtained by casting the metal into an open steel mold at room temperature, 2 in. in diameter and $\frac{5}{8}$ in. deep. The faces of these castings were machined parallel and the Brinell impression always made on the bottom or chill face.

Three impressions were made, using a 10-mm. ball and 500-kg. load applied for 30 seconds, on each specimen at equidistant points on a circle one-half the radial distance from the center. The average of the three impressions was taken as the Brinell hardness number of the alloy under the given conditions.

Some special Brinell tests were made at normal temperatures using lower loads in order to determine if equally representative values are obtained. Compression tests were made on specimens 3 in. in length by 1 in. in diameter to determine the effect of size of specimen on compression test results. These are reported under "Miscellaneous Tests."

The liquidation points of the alloy were determined by the customary method of thermal analysis using the inverse rate cooling curve method.

TABLE III.—PHYSICAL PROPERTIES OF WHITE METAL BEARING ALLOYS.

Alloy No.	Yield Point, B. S. Alloys, lb. per sq. in.		Ultimate Strength, B. S. Alloys, lb. per sq. in.		Brinell Hardness. 500-kg. load; 10-mm. ball, 30 sec.						Temperature of Complete Liquation,[1] B. S. Alloys, deg. Cent.	Melting Point,[1] deg. Cent.
					20° C.			100° C.				
	20° C.	100°C.	20° C.	100°C.	B. S.	A.	B.	B. S.	A.	B.		
1	4400	2650	12850	6950	17.2	18.5	18.9	8.2	9.7	9.2	...	223
2	6100	3010	14920	8680	24.3	27.1	22.4	12.2	11.9	10.7	354	241
3	6620	3150	17590	9890	27.2	30.1	29.5	14.6	14.1	14.3	422	240
4	5550	2160	16160	6900	24.3	27.7	27.2	11.9	10.5	10.8	306	184
5	5050	2140	15030	6730	22.3	24.7	26.3	10.2	9.3	9.8	296	181
6	3790	2040	14530	8050	20.8	23.2	25.5	10.5	10.3	11.2	277	181
7	3550	1580	15640	6170	22.7	22.6	22.9	10.5	9.8	9.8	268	240
8	3400	1740	15620	6160	19.8	21.4	21.4	9.6	9.2	9.0	272	237
9	3400	1570	14710	5850	19.1	20.1	19.5	8.5	8.3	8.1	256	237
10	3350	1850	15430	5770	17.3	20.3	17.0	9.2	9.5	7.7	264	242
11	3040	1380	12820	5100	15.0	17.6	14.7	7.0	7.5	6.1	262	244
12	2800	1260	12880	5100	14.6	17.0	13.9	6.6	7.4	5.8	259	245

[1] The author is indebted to Miss J. S. Hromatko for all melting point data.

TEST RESULTS.

The results of the compression, hardness and cooling curve tests are given in Table III.

DISCUSSION OF RESULTS.

It is evident from Table III that in the tin base alloys the yield point, ultimate strength and hardness increase with increasing amounts of antimony. It is of interest to note, however, that while there is considerable difference of properties at 20° C. between Alloys Nos. 1, 2 and 3, the difference at 100° C. is not so marked. In the case of Alloys Nos. 4 and 5 the effect of the high percentage of lead is very evident, the compressive strength and hardness dropping in spite of the increased antimony content, particularly at 100° C.

The lead base alloys in general have lower compressive properties than the tin base alloys and the lead base alloys containing tin have higher values than those not containing tin. This difference is more marked at 100° C., again indicating the more rapid softening of lead base alloys as compared to tin base alloys with increasing temperatures.

In comparing the Brinell hardness values of the alloys made at the Bureau of Standards with those made commercially, it is to be noted that in general the hardness of the commercial alloys at 20° C. is greater, the maximum difference being 4.7 in both cases as between the two commercial alloys and between the commercial alloys and the Bureau of Standards alloys. The differences at 100° C. are not so marked and are probably all within experimental error.

THERMAL ANALYSIS.

Inverse rate cooling curves were made on the twelve alloys prepared at the Bureau of Standards. The temperatures of primary solidification or complete liquation and the freezing points are given in Table III. The temperatures of complete liquation given are approximate only because the change in slope of the cooling curve at the temperature of primary solidification is gradual and not sharp like a eutectic arrest, making it very difficult to determine the exact temperature at which there is a change in the slope of the curve.

MISCELLANEOUS TESTS.

Compression Tests.—Compression tests were made at 20° C. on specimens 3 in. in length by 1 in. in diameter in order to determine the effect of size of specimen, keeping other factors constant, particularly the ratio of length to diameter, on the yield point and ultimate strength values.

The results obtained were substantially the same as obtained on the small size specimens, but it was much easier to align the smaller specimen in the testing machine and to obtain check results.

Brinell Hardness at 100-Kg.—Brinell hardness tests using a 100-kg. load were made on all the twelve alloy specimens prepared at the Bureau on which the 500-kg. load tests were made, the impressions of the 100-kg. load being made at points midway between the 500-kg. tests. The 100-kg. load was obtained on a Rockwell hardness tester, the diameter of impression being measured and the hardness calculated by the usual formula. The results obtained are given in the following table:

ALLOY NO.	BRINELL HARDNESS 100 KG.	BRINELL HARDNESS 500 KG.
1	18.2	17.2
2	24.6	24.3
3	29.4	27.2
4	24.8	24.3
5	23.8	22.3
6	23.0	20.8
7	24.2	22.7
8	21.0	19.8
9	19.6	19.1
10	17.6	17.3
11	15.8	15.0
12	15.8	14.6

It will be noted that the hardness values obtained using a 100-kg. load are slightly but consistently higher than the values obtained using a 500-kg. load. Intermediate loads would probably give intermediate values.

CONCLUSIONS.

In the tin base alloys the difference in physical properties is greater at normal temperature than at 100° C.

The lead base alloys in general have lower compressive strength.

The presence of lead in an alloy causes a more rapid softening with increasing temperature.

The alloys made under commercial conditions have in general at normal temperatures a higher Brinell hardness than the alloys prepared from pure metals under laboratory conditions.

A cylindrical compression test specimen 3 in. in length by 1 in. in diameter gives the same results as the $1\frac{1}{2}$ by $\frac{1}{2}$-in. specimen but the smaller specimen is easier to handle and gives more consistent results.

The Brinell hardness tests using a 100-kg. load give results which are slightly but consistently higher than values obtained using a 500-kg. load. This indicates that all loads between 100 kg. and 500 kg. should give results comparable with the 500-kg. load usually used.

Acknowledgment is made to R. W. Woodward under whose supervision much of the work was carried out and to Paul F. Brandt who made most of the physical tests.

APPENDIX II.

ANALYSES ILLUSTRATING THE IMPORTANCE OF THE PROPER SAMPLING OF MATERIAL.

BY G. E. F. LUNDELL.[1]

The following analyses were the result of correspondence in June, 1919, with H. E. Smith, who was then with the Railroad Administration and was having difficulty in getting concordant analyses by different chemists working on the same sample. A journal bearing was sampled on the milling machine and the chips then thoroughly mixed and sieved to get the four lots analyzed below:

	SIZE OF PARTICLES.					
	20-MESH	20 TO 30-MESH.	30 TO 80-MESH.	80-MESH TO DUST.	DESIRED COMPOSITION.	PERMISSIBLE VARIATION.
Copper, per cent..	70.00	70.2	67.6	63.2	70	±1.50
Lead, per cent....	24.4	24.1	27.9	31.2	25	±1.50
Tin, per cent.....	4.9	4.9	4.7	4.4	5	±0.50

Other elements not determined.

The data show that very large errors are possible in the analysis of material composed of coarse to very fine particles, unless great care is taken in selecting the small weighed sample for analysis. These errors are apart from those which may be introduced through careless sampling of segregated material.

On acount of the difficulty in properly sampling for small weights of a heavy material of coarse to fine particles, detailed directions should be given for sampling, which should preferably aim at obtaining chips of uniform mesh.

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[1] Chemist, U. S. Bureau of Standards, Washington, D. C.

APPENDIX III.

A LIST OF ALLOYS.

BY WILLIAM CAMPBELL.[1]

In order to show the difficulties which are met with when an attempt is made to formulate a logical and scientific classification of alloys, the following list of alloys has been compiled.

The subject of nomenclature is one of some difficulty. Brass has been defined as an alloy of copper with zinc as the principal alloying metal, whereas bronze is a copper alloy in which tin is the chief added element, and yet it is the custom to call red brass by the name of "bronze." Again, Tobin "bronze," manganese "bronze," etc., are, properly speaking, brasses.

While this list is primarily one of non-ferrous alloys, there have been added a few examples of what are, properly speaking, iron alloys (in contra-distinction to steel) in which the properties are dependent on the added elements, as, for example, in the list of non-corrosive alloys and of the heat-resisting alloys as well as those used for resistance purposes.

It often happens that when a new alloy is brought out its composition is apparently new, but on referring to some of the older books on metals and alloys we find it mentioned under another name. Numerous alloys can be found in such works as Bischoff (1865), Berlin; Bolley (1869), Paris; Guettier (Fesquet); Thurston (Part 3); Law's Alloys; R. A. Wood's "The Waterbury Book of Alloys," etc.

In 1911, Kaiser published a very complete list of metals and alloys in *Metallurgie* (1911), Vol. VIII, pp. 257, 296.

In 1918, the *Metal Industry* of London published a small booklet entitled "Metals and Alloys" which covered Kaiser's list with some few additions.

While both of these lists are useful in that they are arranged alphabetically, for our purpose an arrangement by groups is better in that it shows the wide variations in composition in many of our commercial alloys. In the accompanying list, therefore, this method has been followed, using Kaiser's list as a basis and adding to it such other alloys as have been found in the literature or met with in practice.

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[1] Professor of Metallurgy, School of Mines, Columbia University.

The arrangement of groups is as indicated below, the page number on which each group may be found being included for easy reference.

PAGE
Brasses 215
Bronzes 219
Copper Nickel Alloys 224
Nickel Silver (Agiroide, Alfenide, Argentan, Arguzoid, Argyrolith, Electrum, Neusilber, Nickelin, Maillechort, Packfong, Sterlin, Tutenag, White Copper, etc.) 224
Aluminum Bronzes, etc 227
Copper Manganese Alloys 228
Aluminum Alloys 229
Tin Base Alloys 232
Lead Base Alloys 234
Zinc Base Alloys 236
Fusible Metals 237
Gold Alloys 238
Silver Alloys 239
Platinum, etc 239
Resistance Alloys 239
Heat Resisting 241
Non-Corrosive Alloys 241

It is realized that this list is incomplete and additions or corrections will be very welcome.

BRASSES.

	Cu	Zn	Sn	Pb	Fe	Other Elements
Admiralty, A	70.	29.	1.	....	....	
Aitch Metal	60.	38.2	....	....	1.5	
Aluminum Brass	63.	33.3	....	....	....	Al, 3.3; Si, 0.3
Anvil Brass	62.50	37.50	....	....	....	
Arko	80.	20.	....	....	....	
Augsburg	71.9	27.6	....	....	....	
Austrian Journal Box	92.5	7.5	....	....	....	
Bath Metal	55.	45.	....	....	....	
Bath Metal	83.	17.	....	....	....	
Battery Copper	94.00	6.00	....	....	....	
Bell Brass	64.25	35.00	0.75	....	....	
Belt Lace	62.00	38.00	....	....	....	
Best Bronze	90.00	10.00	....	....	....	
Binding Brass	63.25	35.00	....	1.75	....	
Birmingham Platina	46.6	53.15	....	....	0.25	
Bismuth Brass	47.	21.	1.	....	....	Ni, 30.9; Bi, 0.1
Blatt Gold	77.	23.	....	....	....	
Block Brass	66.50	32.00	....	1.50	....	
Bobierre Metal	66.	34.	....	....	....	
Bobierre Metal	58.2	41.7	....	....	....	
Bow Wire	93.00	2.00	5.00	....	....	
Brazing Metal, F	85.	15.	....	....	....	
Brazing Brass	75.00	25.00	....	....	....	
Bright Cap Gilding	89.75	9.87	....	0.38	....	
Bristol	75.7	24.3	....	....	....	
Bristol	67.2	32.8	....	....	....	
Bristol	60.8	39.2	....	....	....	
Bronze Powder	84.0	16.0	....	....	....	
Brush Wire	64.25	35.	0.75	....	....	
Buckle Brass	65.00	35.	....	....	....	
Bullet Brass	90.	9.	....	1.	....	
Burr Brass	62.00	38.00	....	....	....	
Burr Metal	90.00	10.00	....	....	....	
Butt Brass	65.50	33.50	....	1.	....	
Butt Brass	63.50	35.50	....	1.	....	
Button Brass	89.50	10.00	0.50	....	....	
Button Metal	43.	57.	....	....	....	
Button Metal, Ludensheidt	20.	80.	....	....	....	
Buttons (Thurston):						
Bristol Alloy	57.9	36.8	5.3	....	....	
Bristol Alloy	61.12	36.11	2.77	....	....	
Jackson's Alloy	63.88	30.55	5.55	....	....	
Jackson's Alloy	63.01	35.61	1.39	....	....	
"Bidery"	48.50	33.32	6.06	12.15	....	
"Gold"	58.71	33.03	5.50	2.75	....	
Cap Gilding	90.00	10.00	....	....	....	
Cartridge Brass	66.67	33.33	....	....	....	
Cartridge Brass	68.00	32.00	....	....	....	
Cartridge Brass	70.00	30.00	....	....	....	
Cartridge Gilding	93.00	7.00	....	....	....	
Chamet Bronze	62.	38.	....	....	....	
Check Brass	62.	38.	....	....	....	
Chrysokalk	90.5	7.9	....	1.6	....	
Chrysokalk	58.7	40.2	....	1.1	....	
Chrysorin	72.	28.	....	....	....	
Chrysorin	66.7	33.3	....	....	....	
Chrysorin	63.3	36.7	....	....	....	
Clinching Screw Wire	69.	29.50	....	1.50	....	
Clock Brass	62.50	35.75	....	1.75	....	
Collet Brass	61.00	36.50	....	2.50	....	

BRASSES (*Continued*).

	Cu	Zn	Sn	Pb	Fe	Other Elements
Commercial Bronze	90.00	10.00	....	....	....	
Commercial Brass, B-r	63.	37.	....	....	....	
Commercial Castings, B-c	62.	30.	6.	2.	....	
Common Brass	65.	35.	....	....	....	
Cuivre Poli	70.	30.	....	....	....	
Cymbal Metal	78.	22.	....	....	....	
Delatot's Metal	80.	18.	....	....	....	Mn, 2.0
Delta Metal	55.1	43.5	....	0.37	1.08	P, 0.1
Delta Krupp	55.94	41.61	....	0.72	0.87	Mn, 0.81; P, 0.013
Delta Krupp	55.8	40.07	....	1.82	1.28	Mn, 0.96
Delta Krupp	55.82	41.41	....	0.76	0.86	Mn, 1.38
Delta Krupp	54.22	42.25	....	1.10	0.99	Mn, 1.09
Diaphragm Brass	95.00	2.00	3.	....	....	
Dipping Brass	66.66	33.34	....	....	....	
Door Plate Brass	65.	35.	....	....	....	
Door Plate Brass	63.	35.	....	2.00	....	
Doctor Metal	88.	9.50	2.50	....	....	
Drawing Brass, Deep	70.	30.	....	....	....	
Drawing Brass	66.67	33.33	....	....	....	
Drill Rod	62.	35.50	....	2.50	....	
Durana	65.	30.	2.	....	1.5	Al, 1.5
Dutch Metal	76.	24.	....	....	....	
Electrical Brass Castings, B. E.	84.	13.	3.	....	....	
English	70.3	29.3	0.17	0.26	....	
Engravers' Brass	66.	33.	....	1.00	....	
Escutcheon Pin Brass	64.50	35.07	....	0.43	....	
Eyelet Brass	68.	32.	....	....	....	
Eyelet Brass	65.	35.	....	....	....	
Fan Blades	61.50	37.00	....	1.50	....	
Flush Plate	65.75	32.75	....	1.50	....	
Fob Metal	87.50	12.00	0.50	....	....	
Forbes Metal (Button)	46.5	53.5	....	....	....	
Forgings	60.	40.	....	....	....	
Forgings	57.	43.	....	....	....	
Forgings, Russian	53.5	42.	....	....	....	Mn, 4.5
Fourdrinier Wire	84.63	15.	0.37	....	....	
Fourdrinier Wire	80.	20.	....	....	....	
Free Cutting Bronze	88.50	10.00	....	1.50	....	
Gedges Metal	60.	38.5	....	....	1.5	
Gold Leaf Metal	84.	16.	....	....	....	
Gold Leaf	66–80	34–20	....	....	....	
Gold Leaf Jemmapes	64.6	33.7	1.4	0.2	....	
Gold Leaf Aix	64.8	32.8	2.0	0.4	....	
Gong Metal	78.	22.	....	....	....	
Grommet Brass	70.	30.	....	....	....	
Guettier's Button	56.	44.	....	....	....	
Guettier's Button	61.5	32.	6.5	....	....	
Guettier's Button	61.4	28.9	9.7	....	....	
Hamilton Metal	66.7	33.3	....	....	....	
Halberland Alloy	87.	13.	....	....	....	
Hardware Bronze	88.	12.	....	....	....	
Hardware Bronze	88.	9.50	1.50	1.00	....	
Harlington Bronze	55.7	42.7	0.97	....	0.58	
Harmonia Bronze	57.	40.	....	0.4	1.8	
Harmonia Bronze	55.7	41.2	0.5	0.46	1.29	Al, 0.86
Helmet Bronze	70.	30.	....	....	....	
Helmet Metal	72.27	27.58	....	....	....	
Hooker Brass	61.	37.	....	2.00	....	
Iserlohn, Cast	63.7	33.5	2.5	0.3	....	
Jewelers Metal	91.50	6.50	2.00	....	....	

BRASSES (*Continued*).

	Cu	Zn	Sn	Pb	Fe	Other Elements
Jewelers Metal	90.	10.	....	....	....	
Jewelers Metal	83.	17.	....	....	....	
Jewelers Metal	88.	11.25	0.75	....	....	
Jewelers Metal	87.50	12.	0.50	....	....	
Jewelers Metal	91.	7.50	1.50	....	....	
Kick Plate Brass	84.	15.	....	1.00	....	
Lancashire Brass	73.	25.	....	2.00	....	
Leaded Bronze	88.50	10.00	....	1.50	....	
Low Brass	80.00	20.00	....	....	....	
Machinery Brass	83.	16.	1.	....	....	
Mallet Alloy	25.4	74.6	....	....	....	
Manganese Brass	69.5	29.5	....	....	....	Mn, 1.0
Manganese Brass	60.15	34.76	0.94	0.39	1.19	Mn, 2.34; Al, 0.2
Manganese Brass	55.4	39.96	....	....	1.6	Mn, 3.20; Al, 0.2
Manganese Brass	55.0	39.5	....	....	0.7	Mn, 4.3; Al, 0.5
Manganese Brass	54.2	38.2	....	....	2.4	Mn, 4.4; Ni, 0.5
Manganese Brass	85.	2.0	....	....	1.83	Mn, 10.91
Manganese Brass	80.	5.	....	....	....	Mn, 15.
Manganese Brass	75.5	8.	....	....	....	Mn, 16.5
Manganese Brass	60.	15.	....	....	....	Mn, 25.
Mn Ni Brass	65.	5.	....	....	....	Mn, 20.; Ni, 10.
Mn Ni Brass	59.	20.	....	....	....	Mn, 3; Ni, 18
Mn Ni Brass	63.5	28.28	1.22	0.17	1.44	Mn, 3.24; Ni, 2.14
Mn Ni Brass	51.15	40.	....	....	2.25	Mn, 4.15; Ni, 2.2; Al, 0.25
Mn Ni Brass	53.5	39.	.07	....	2.78	Mn, 1.52; Ni, 2.35
Mn-Bronze, Rolled, Mn-r	59.	30.7	1.	....	....	Mn, 0.3
Mn-Bronze, Cast, Mn-c	58.	40.	....	....	....	Mn, 2.
Manganin	53.4	39.	2.66	....	....	Ni, 2.5; Mn, 1.7; Al, 0.2
Manheim Gold	89.4	9.92	0.62	....	....	
Manheim Gold	83.7	9.3	7.	....	....	5 per cent of Phos. Tin
Manheim Gold	88.	12.	....	....	....	
Manheim Gold	80.	20.	....	....	....	
Market Brass	65.	35.	....	....	....	
Matrix Brass	62.	36.50	....	1.50	....	
Medal Metal	84.00	16.00	....	....	....	
Mosaic Gold	63.	35.	....	....	....	
Muntz Metal	60.	40.	....	....	....	
Naval Brass, N-c	61.	38.	1.	....	....	
Neustadt, Drawn	71.5	28.5	....	....	....	
Nickel Brass	54.1	43.66	....	....	0.5	Ni, 1.5
Oker, Cast	71.9	24.4	....	1.1	2.32	
Oker Brass (Harz)	64.24	37.27	0.59	0.12	....	
Optical Bronze	89.00	6.50	4.50	....	....	
Oreide	87.25	11.50	1.25	....	....	
Oreide	90.	10.	....	....	....	
Oreide	85.5	14.5	....	....	....	
Oreide	80.5	14.5	4.85	0.1	....	
Oreide, Brunswick	68.21	31.52	0.48	....	....	
Parson's Mn Bronze	60.15	34.76	0.94	0.39	1.19	Mn, 2.34; Al, 0.23
Pen Metal	85.00	13.00	2.00	....	....	
Percussion Cap	95.00	5.00	....	....	....	
Pewter (Thurston):						
Berthier's Alloy	71.9	24.9	1.2	2.0	....	
Cast and worked	64.2	34.6	0.2	2.0	....	
Cast and worked	61.6	35.3	0.6	2.5	....	
Cast gilt	63.7	33.5	2.5	0.3	....	
Cast gilt	64.5	32.4	0.2	2.9	....	
For clock work	60.66	36.88	1.35	0.74	....	
For clock work	60.06	31.46	1.43	0.88	....	
Pinchbeck	93.6	6.4	....	....	....	

BRASSES (*Continued*).

	Cu	Zn	Sn	Pb	Fe	Other Elements
Pinchbeck	88.8	11.2	....	....	....	
Pinchbeck	83.33	16.76	....	....	....	
Pin Wire	61.00	39.00	....	....	....	
Platine	43.	57.	....	....	....	
Potinjaune	71.9	24.9	1.2	2.0	....	
Primer Gilding	97.00	3.00	....	....	....	
Prince's Metal	83.	17.	....	....	....	
Prince's Metal	75.	25.	....	....	....	
Prince's Metal	60.8	39.2	....	....	....	
Reed Brass	69.00	30.00	1.00	....	....	
Rich Gold Metal	90.00	10.00	....	....	....	
Rich Low Brass	85.00	15.00	....	....	....	
Rule Brass	62.50	35.00	....	2.50	....	
Rubel Metal	55.	40.	....	....	....	5 per cent of Al-Fe-Mn-Ni Alloy
Rubel Metal	51.	40.	....	....	....	5 per cent of Al-Fe-Mn-Ni Alloy and 4 per cent of Ferro Mn
Russian, Cast	78.	21.	1.	....	....	
Russian, Cast	70.	30.	....	....	....	
Russian, Cast	66.6	33.4	....	....	....	
Screen Plates	58.00	41.00	0.75	0.25	....	
Screw Bronze	93.50	5.00	1.00	0.50	....	
Screw Brass	78.	16.	4.5	1.5	....	
Screw Wire	62.00	38.00	....	....	....	
Seamless Tubing	60.00	40.	....	....	....	
Seamless Tubing	61.50	38.50	....	....	....	
Solder, Hard	57.	43.	....	....	....	
Solder, Hard	50.	50.	....	....	....	
Solder, White	40.	60.	....	....	....	
Solder (Thurston):						
Yellow, Hard	53.30	43.10	1.30	0.30	....	
Nearly White, Soft	44.	49.90	3.30	1.20	....	
White, Very Soft	57.44	27.98	14.58	....	....	
Sheet:						
Stollberg	64.8	32.8	0.4	2.0	....	
Jamappes	64.6	33.7	0.2	1.4	....	
Rosthorn-Wiln	68.1	31.9	....	....	....	
Oker I	69.	29.5	....	0.97	....	
Oker	55.	44.5	0.5	....	....	
Iserlohn	70.1	29.9	....	....	....	
Romilly	70.1	29.26	0.17	0.28	....	
China	56.6	38.2	3.3	1.0	1.40	
Japan	66.6	33.4	....	....	....	
Hegermuhl	72.16	27.45	0.2	0.79	....	
Hegermuhl	72.	27.	1.	....	....	
Hegermuhl	62.	37.	0.5	0.5	....	
Hegermuhl	62.	37.	1.	....	....	
Shell Head Brass	75.00	25.00	....	....	....	
Shoe Nail Brass	63.00	37.00	....	....	....	
Shoe Tip Metal	88.00	12.00	....	....	....	
Similor	89.4	9.93	0.6	....	....	
Similor	83.7	9.3	7.0	....	....	
Similor	80.	20.	....	....	....	
Spring Brass	72.00	28.00	....	....	....	
Spring Brass	66.67	33.33	....	....	....	
Sterro Metal	60.	38.2	....	....	1.8	
Sterro Metal	55.	42.4	0.83	....	1.8	
Sterro Metal	55.5	42.	....	....	2.5	
Sterro Metal	55.3	41.8	....	....	4.66	

BRASSES (*Continued*).

	Cu	Zn	Sn	Pb	Fe	Other Elements
Sterling	66.2	33.1	....	....	0.7	
Stirling, Cast	66.2	33.11	....	0.02	0.66	
Talmi Gold	90.	8.92	....	....	....	Au, 0.91
Talmi Gold	86.4	12.2	1.1	....	0.3	
Thurston's	55.	44.5	0.5	....	....	
Tissier's	97.	2.0	0.5	....	....	
Tissier's	97.	2.0	....	....	....	As, 1.0
Tobin Bronze	60.	38.	2.	....	....	
Tobin Bronze	59.	39.	2.	....	....	
Tombac:						
Oker	85.3	14.7	....	....	....	
Arcet	82.3	17.7	....	....	....	
Ludenscheidt	82.3	17.5	....	....	....	
Red Vienna	97.8	2.2	....	....	....	
Sheet, Paris	92.	8.	....	....	....	
Sheet, Paris	88.	12.	....	....	....	
Sheet, Paris	84.	16.	....	....	....	
Golden	82.	17.5	0.5	....	....	
French	80.	17.	3.	....	....	
French	80.	20.	....	....	....	
Cast	87.	13.	....	....	....	
Common	71.5	28.5	....	....	....	
Tournay's	82.54	17.46	....	....	....	
Tubes, etc.:						
German	70.	30.	....	....	....	
German	60.	40.	....	....	....	
Russian	66.	34.	....	....	....	
Russian	59.72	38.62	0.16	0.34	1.1	
English	65.	35.	....	....	....	
Admiralty	70.	29.	1.0	....	....	
Turbiston's	55.	41.	....	....	0.84	Ni, 2; Al, 1.0; Mn, 0.16
Tungsten Brass (Ni, 0.75)	59.73	33.97	0.15	....	....	Al, 2.8; W, 2.; Mn, 0.7
Turbine Brass	75.77	24.07	....	....	....	
Turbine Brass	67.35	32.02	....	0.23	0.38	
Vanadium Bronze Vn-c	61.	38.5	....	....	....	Va, 0.5
Vanadium Brass	70.	29.5	....	....	....	Va, 0.5
Washer Brass	62.00	38.00	....	....	....	
Wheel Brass	68.00	30.00	....	2.00	....	
Wire	70.29	29.26	0.17	0.28	....	
Wire, English	70.29	29.36	0.28	0.17	....	
Wire, Augsburg	71.89	27.33	....	0.85	....	
Wire, Common	65.4	34.6	....	....	....	

BRONZES.

	Cu	Sn	Zn	Pb	P	Other Elements
Acid Bronze	88.00	10.00	....	2.00	....	
Acid Bronze	82.00	8.00	2.00	8.00	....	
Acid Bronze	84.00	9.50	....	6.30	0.20	
Ajax Plastic	64.00	5.00	....	30.00	....	Ni, 1.
Ajax Phosphor	79.30	10.00	....	10.00	0.7	
Allan Red Metal	50.00	....	....	50.00	....	S, 0.25
Allan Red Bronze	62.50	7.50	....	30.00	....	
Amax Metal	81.30	11.00	....	7.40	0.3	
Argental	85.00	10.00	....	....	....	Co, 5.0
Argozoil	54.	2.	28.00	2.	....	Ni, 14.0
Arsenic	79.7	10.00	....	9.50	....	As, 0.8

BRONZES *(Continued)*.

	CU	SN	ZN	PB	P	OTHER ELEMENTS
Bearing Bronze (Kaiser):						
Locomotive	74.	10.	9.	7.	....	
Prussian	84.	15.	1.	....	....	
Belgian	80.	16.	....	2.0	....	Sb, 2.
French (Northern)	82.	10.	8.	....	....	
Russian	77.	10.2	5.1	7.7	....	
Railroad Cars	82.	18.	....	....	....	
Railroad Cars	84.	16.	....	....	....	
Railroad Cars	75.	20.	5.	....	....	
Rheinland	86.	12.	2.	....	....	
E.B.D., Breslau	88.	10.	2.	....	....	5 per cent of P Sn
E.B.D., Berlin	90.	10.	....	....	....	
Automobile	88.	8.	....	3.	....	1 per cent of P Sn
Automobile	78.	8.	1.	12.	....	1 per cent of P Sn
Automobile	80.	10.	....	8.	....	2 per cent of P Sn
Various	83.	14.	2.	1.	....	
	83.7	14.2	2.1	....	....	
	85.5	12.8	1.7	....	....	
	83.	12.	5.	....	....	
	85.	11.	4.	....	....	
	74.5	9.5	8.9	7.1	....	
	77.	9.	14.	....	....	
	83.7	8.8	7.5	....	....	
	84.	8.	....	8.	....	
	81.	7.	3.	9.	....	
	78.	7.	....	15.	....	
	70.	6.5	2.	1.5	....	
	86.	6.	5.	....	....	Mn, 2.7
	72.4	4.7	29.9	1.5	....	
	75.	4.	21.	....	....	
Bearings of Engines	79.	8.	5.0	8.0	....	
Bearings and Valves	80.	16.	....	2.	....	Sb, 0.2
Bell Metal	75–80	25–20	....	....	....	
"Best"	78.	22.	....	....	....	
Reichenhall, 600 years	76.2	23.8	....	....	....	
Reichenhall, 300 years	80.	20.	....	....	....	
Old Bell at Rouen	71.	26.	1.8	1.2	....	
Damstadt	73.94	21.67	....	2.11	....	Fe, 0.19; Ni, 2.
Damstadt	72.52	21.06	....	2.14	....	Fe, 0.05; Ni, 2.66
Musical	84.	16.	....	....	....	
House	80.	20.	....	....	....	
Clock	75.	25.	....	....	....	
Herbohn	60.	35.	5.0	....	....	
Herbohn	71.43	26.4	2.7	....	....	
Karakane	71.42	14.2	....	14.3	....	
Karakane	70.	19.	3.	8.	....	
Karakane	65.95	17.25	3.45	10.35	....	
Karakane	64.	24.	9.	....	....	Fe, 3.0
Karakane	62.5	25.	9.4	....	....	Fe, 3.1
Karakane	61.	18.	6.	12.	....	Fe, 3.0
Bilgen-Bronze	97.32	1.89	....	0.24	....	Fe, 0.52
Bridge Bronze A	80.	20.	....	....	0.1	
Bridge Bronze B	85.	15.	....	....	0–1	
Bridge Bronze C	80.	10.	....	10.	0.7–1	
Bridge Bronze D	88.	10.	2.	....	0.25	
Bismuth Bronze	53.	15.	20.	....	....	Ni, 10.; Al, 1.; Bi, 1.
Brasses	74.4	9.5	8.9	7.1	....	
Brasses	70.	10.	10.	10.	....	
Brasses	74.	1.0	10.	15.	....	
Bushings	86.2	10.2	3.6	....	....	

BRONZES (*Continued*).

	Cu	Sn	Zn	Pb	P	Other Elements
Bushings	85.	11.	4.	....	....	
Camelia	70.4	4.2	10.2	14.7	....	Fe, 0.5
Carbon	75.4	9.7	....	14.5	....	
Carriage Wheel Bearing	84.	16.	....	....	....	
Chinese	72.5	4.7	14.3	18.5	....	
Chinese	74.	1.0	10.	15.	....	
Cocks	88.	10–8.	2–6.	....	....	
Cogs and Worms	85.	11.	4.	....	....	
Coinage	95.	4.	1.	....	....	
Cooper's Speculum	57.8	27.3	3.6	....	....	As, 1.2; Pt, 10.
Cornish	77.8	9.6	....	....	0.8	
Damascus	77.	10.5	....	12.5	....	
Damar	76.4	10.6	....	12.5	....	
Daimler Bearing	76.	3.	20.	1.	....	
Dudley's B	77.	8.	....	15.	....	
Dudley's K	77.	10.5	....	12.5	....	
Dudley's Phosphor	79.7	10.	....	9.6	0.8	
Durena	65.	2.	30.	....	....	Al, 1.5; Fe, 1.5
Dysoid	62.	10.	10.	18.	....	
Edward's Speculum	63.3	32.2	....	....	....	As, 1.6
Edward's Speculum	69.8	25.1	2.6	....	....	As, 2.4
Eisen-Bronze	82.5	8.55	4.45	....	....	Fe, 3.95
Eislers	94.1	5.9	....	....	....	
Eccentric Ring	84.	14.	2.	....	....	
File Bronze	64.4	18.	10.	7.6	....	
File Metal (Genfer)	64.4	18.	10.	7.6	....	
File Metal (Genfer)	62.	20.	10.	8.	....	
File Metal (Vogel)	73.	19.	8.	8.	....	
File Metal	61.5	31.	....	8.5	....	
File Metal	51.	28.5	7.	7.	....	
Flange Metal (German)	92.4	2.5	5.05	....	....	
Flange Metal (French)	94.35	5.6	....	0.05	....	
Gearing	91.3	8.7	....	....	....	
Gear Bronze	88.	10.	....	....	2.	
Gear Bronze	85.	13.	2.	....	....	
Gears	85.	10.	3.	2.	....	
Gun Metal	90.	10.	....	....	....	
French, Modern	90.1	9.9	....	....	....	
French, Old	89.44	8.91	1.39	0.16	....	
Prussian, Modern	90.9	9.1	....	....	....	
English, Modern	89.3	10.7	....	....	....	
English, Modern	91.74	8.26	....	....	....	
Russian, Modern	90.8	9.2	....	....	....	
Russian, 1813	88.61	10.7	....	....	....	Fe, 0.69
Swiss (Lucern)	88.93	10.37	0.42	....	....	
Cochin China	77.18	3.42	5.02	13.22	....	Fe, 1.16
Cochin China	93.19	5.43	....	....	....	Fe, 1.38
Chinese, Old	71.16	....	27.36	....	....	Fe, 1.40
Chinese, 1901	93.2	5.05	....	....	....	Fe, 1.72
Turkish, 1464	95.2	4.31	....	....	....	
Turkish, 1907	90.9	8.8	....	....	....	Fe, 0.2
Gun Mount	80.	3.	17.	....	....	
Graney Bronze (Law)	75.8	9.2	15.	....	....	
Gurney's	75.8	9.2	15.	....	....	
Hercules	85.5	10.	2.	....	....	Al, 2.5
High Temperature	90.7	2.7	6.3	1.3	....	
Hydraulic	83.0	10.8	6.0	0.1	....	
Instrument	82.	13.	5.	....	....	
Instrument	82.1	12.8	5.1	....	....	
Johnson Locomotive Bearing	87.5	7.85	5.07	....	....	

BRONZES (*Continued*).

	Cu	Sn	Zn	Pb	P	Other Elements
Kern's Hydraulic	78.	12.	10.	....	....	
Kochlin's Bearing	90.	10.	....	....	....	
Kuhne Phosphor Bronze	78.	10.6	....	10.45	0.57	Ni, 0.26
Lafond's Bronze	83.	15.	1.5	0.5	....	
Lafond's Axle Bearing	80.	18.	2.	....	....	
Lafond's Straps	84.	14.	2.	....	....	
Lafond's Pumps	88.	10.	2.	....	....	
Lafond's Heavy Bearing	83.	15.	1.5	0.5	....	
Lafond's Malleable	98.04	1.96	....	....	....	
Lowroff Phosphor Bronze	70.	13.	....	16.	1.	
Lowroff Phosphor Bronze	90.	4.	....	5.5	0.5	
Laderig's Speculum	69.	28.7	....	....	....	
Medal	92.	8.	....	....	....	
Medal	97.	1.	2.	....	....	
McKechnie's	57.	41.	1.	0.5	....	Fe, 1.
Manheim Gold	83.7	7.	9.3	....	....	5 per cent of Phos. Tin
Manganese Bronze	82.	8.	5.	3.	....	Mn, 2.0
Manganese Bronze	83.5	8.	5.	3.	....	Mn, 0.5
Mudge's Speculum	68.82	31.18	....	....	....	
Needle	84.5	8.	5.5	2.	....	
Nongran	87.	11.	2.	....	....	
Neogen	58.	2.	27.	....	....	Ni, 12.; Al, 0.5; Bi, 0.5
Naval Gun Metal, G	88.	10.	2.	....	....	
Naval Journal, H	83.	13.5	3.5	....	....	
Naval Journal, HX	83.	13.5	....	3.5	....	
Naval Valve, M	87.	7.	6.	....	....	
Naval Phosphor, Cast, P-c	88.	8.	2.5	....	0.5	
Naval Phosphor, Rolled, P-r	95.	4.5	....	....	0.5	
Oil Cups	85.	5.	7.	....	....	
Oil Pump	83.	3.	9.	....	3.	
Ounce Metal	85.	5.	5.	5.	....	
Ormulu	58.	16.7	23.3	....	....	
Ormulu, small	94.12	5.88	....	....	....	
Ormulu, large	90.5	6.5	3.0	....	....	
Perking Brass	76.2	23.8	....	....	....	
Perking Brass	80.	19.82	0.14	....	....	
Phosphor Bronze:						
Wire	98.75	1.2	....	....	0.05	
Hard	92.8	7.	....	....	0.2	
Very Hard	80.	9.	....	....	1.0	
Rolling	95.6	4.5	....	....	0.1	
Charpy	85.7	12.2	....	....	0.4	
Charpy	84.8	13.4	....	....	0.46	
Law	87.6	10.8	....	....	1.0	
Law	88.7	9.5	....	....	0.7	
Bridge	80.	20.	....	....	1–0.2	
Bridge	85.	15.	....	....	1.	
Bearings	83.	14.	2.	1.	1.	
Bushings	79.	10.	....	10.	0.7	
Gears	88.	10.	....	2.	0.1	
Gears	85.	13.	2.	....	0.1	
Gears	78.	12.	....	7.5	0.1	
English	79.2	10.2	....	9.6	0.97	
Pennsylvania Railroad	79.7	10.	....	9.5	0.8	
Pennsylvania Railroad "B"	76.8	8.	....	15.	0.2	
Pennsylvania Railroad "B"	85.55	9.85	3.77	0.62	0.05	
Pennsylvania Railroad "B"	80.	8.	....	10.	....	2 per cent of Phos. Tin
Russian	93.7	5.8	0.34	....	0.17	
Piston Rings	84.	2.9	8.3	4.3	....	
Piston	83.	1.	16.	....	....	

BRONZES *(Continued)*.

	Cu	Sn	Zn	Pb	P	Other Elements
Railroad (Hughes):						
Slide Valves	84.5	10.	....	5.	0.5	
Injector	84.	8.5	5.	2.5	....	
Phosphor Bronze	88.5	10.	....	....	0.5	
Axle Box Bearing	80.	5.	....	15.	....	
20-Ton Wagon	60.	5.	....	20.	....	
Railroad (Thurston):						
Axle Bearings, French	82.	10.	8.	....	....	
Axle Bearings, Common French	78.	20.	2.	....	....	
Axle Bearings, Lafond	80.	18.	2.	....	....	
Axle Bearings, Hard	87.05	7.88	5.07	....	....	
Eccentric Strap, Dutch	85.25	12.75	2.0	....	....	
Eccentric Strap, Lafond	84.	14.	2.0	....	....	
Gearing	88.8	8.5	2.7	....	....	
Locomotive Bearings	89.	2.4	7.8	....	....	Fe, 0.8
Locomotive, German	81.17	....	15.2	14.6	....	Fe, 0.9
Locomotive, Durable	73.5	9.5	9.5	7.5	....	Fe, 0.5
Pistons and Rods	74.1	3.7	22.2	....	....	
Richardson's Speculum	65.3	30.	0.7	....	....	As, 2.0; Si, 2.
Roman Bronze	90	9.	....	....	....	
Ross' Alloy	68.2	31.8	....	....	....	
Sallit's Speculum	64.6	31.3	....	....	....	Ni, 4.1
Sheet Bronze	90.	10.	....	....	....	
Sheet Phosphor	94.5	5.0	....	....	....	0.5 per cent of Phos. Tin
Sheet Phosphor	95.	4.	....	....	....	1.0 per cent of Phos. Tin
Sashchain	92.	8.	....	....	....	
Sashchain	95.	5.	....	....	....	
Screw-Nut	86.	11.4	2.3	....	....	
Slide Valve	88.5	2.5	9.	....	....	
Steam Fittings	88.	8.	2.	2.	....	
Silicon Bronze	98.55	1.45	....	....	....	Si, 0.05
Silicon Bronze	91.	9.	....	....	....	Si, 0.05
Statuary Bronze:						
Column Vendome	89.2	10.2	0.5	0.1	....	
Column of July, Paris	91.4	1.6	5.6	1.4	....	
Napoleon I, Paris	75.0	3.0	20.	2.0	....	
Henry IV, Paris	89.62	5.7	4.2	0.48	....	
Louis XIV, Paris (1699)	91.4	1.7	5.53	1.37	....	
The Shepherd, Potsdam	88.68	9.2	1.28	0.77	....	
Bacchus, Potsdam	89.34	7.5	1.63	1.21	0.18	
Germanicus, Potsdam (1820)	89.78	6.16	2.35	1.33	....	Ni, 0.27
Mars and Venus, Munich	94.12	4.77	0.3	0.67	....	Ni, 0.48
Bavaria, Munich	91.55	1.77	5.5	1.3	....	
Munich	92.88	4.18	0.44	2.31	0.15	
Munich	77.03	0.91	19.12	2.29	0.12	Ni, 0.43
Augsburg	89.43	8.17	....	1.05	0.34	Ni, 0.19
Augsburg	94.74	1.64	0.54	6.24	....	Ni, 0.71
Grosser Kurfürst, Berlin	89.09	5.82	1.64	2.62	0.13	
Frederick the Great, Berlin	88.3	1.4	9.5	0.7	....	
Melanchton, Wittenberg	89.55	2.99	7.45	....	....	
Speculum, Cu_4Sn	68.25	31.75	....	....	....	
Speculum, English	66.6	33.4	....	....	....	
Speculum, Chinese	80.8	10.7	....	....	....	Sb, 8.5
Speculum, Chinese (Elsner)	80.8	....	....	....	....	Pb, 9.1; Sb, 8
Schmidt Locomotive Bearing	86.	14.	....	....	....	
Seraing Bearing	86.	14.	....	....	....	
Seraing Piston Rings	89.	2.	9.	....	....	
Stephenson, Locomotive Bearing	79.5	7.5	5.0	8.0	....	
Stephenson, Piston Rings	84.	2.9	8.3	4.3	....	Fe, 0.4
Stone's English Gear	89.	11.	....	....	....	

BRONZES (*Continued*).

	Cu	Sn	Zn	Pb	P	Other Elements
Telegraph Bronze	80.	5.	7.5	7.5	....	
Tungsten Bronze	90.	....	....	....	....	W, 10.
Tin Bronze	89.	11.	....	....	....	
Uchatius Bronze	92.	8.	....	....	....	
Ulcony	65.	....	....	35.	....	
Valves	85.	9.	6.	....	....	
Valve Bronze	89.	5.	3.	3.	....	
Valve Bronze	83.	4.	7.	6.	....	
Valve, Steam	88.	10.	2.	....	....	
Weights	90.	8.	2.	....	....	
Whistles	80.	18.	2.	....	....	
Whistles, Lafond	81.	16.	2.	....	....	
Whistles, Lafond	80.	18.	....	....	....	Sb, 2.0
Wire	98.75	1.2	....	....	0.05	

COPPER-NICKEL ALLOYS.

	Cu	Ni	Other Elements.
Locomotive Tubes	97.	3.	
Driving Bands, Sheet	95.	5.	
Benedict Metal, Sheet, Tubes	86–84	14–16	
Blanko-Blech	80.	20.	
Cupro-nickel, Sheet	81–79	19–21	
Imperial Metal	80.	20.	
Turbine Material	79–81	21–19	Fe, 0.75 max.
Coinage	75.	25.	
Constantin, Resistance	60.	40.	
Constantin, Resistance	54.	45.	Mn, 1.0
Ingots for Nickel Silver	50.	50.	
Monel Metal, cast	28.	68.	Fe, 2.; Si, 1.; Mn, 0.25
Monel Metal, forged	28.	68.	Fe, 2.; Mn, 1.5; Si, 0.20

NICKEL SILVER.

(Agiroide, Alfenide, Argentan, Arguzoid, Argyrolith, Electrum, Neusilberg, Nickelin, Maillechort, Packfong, Sterlin, Tutenag, White Copper, etc.)

	Cu	Zn	Ni	Fe	Sn	Pb	Other Elements
Albatra Metal	57.5	22.5	18.75	....	....	1.25	
Ambrac	74.5	5.0	20.0	....	....	....	Mn, 0.50
Argentan:							
Sheet	40–65	17–32	15–20	....	....	....	
Chinese	40.4	25.4	31.6	2.6	....	....	
French	50.32	30.94	18.4	....	....	....	
Berlin	55.5	29.1	15.5	....	....	....	
Vienna	55.6	21.8	22.2	0.38	....	....	
English	63.36	17.01	19.13	0.38	....	....	
Russian	63.88	17.58	17.58	0.33	....	0.32	
Castings, Berlin	48.32	23.8	24.15	3.61	....	....	
Castings, Russian	57.52	18.94	20.35	3.15	....	....	
Solder	35.	57.	8.	....	....	....	
Alpakka	63.94	19.24	14.55	0.4	0.12	0.03	Ag, 2.02
Aluminum Silver	57.	20.	20.	....	....	....	Al, 3.0
American Silver, Cast	49.36	20.7	24.2	1.3	0.45	....	Mn, 3.83; Al, 0.13
American Silver, Cast	57.7	24.2	15.3	0.6	0.69	1.5	
American Silver, Cast	59.11	22.66	11.22	....	....	2.9	Al, 1.5; P Sn, 5.0
Aphit	70.	5.5	20.	....	....	....	Cd, 4.5
Aphit	75.1	2.37	20.75	....	....	....	Cd, 1.8
Arguzoid	55.78	23.2	13.4	....	4.03	3.54	

NICKEL SILVER *(Continued)*.

	Cu	Zn	Ni	Fe	Sn	Pb	Other Elements
Aterite, Cast	66.75	17.25	13.92	1.58	....	0.18	Mn, 0.23; Al, 0.17
Aterite, Rolled	67.76	19.97	12.36	1.51	....	0.07	Mn, 0.16
Aterite, Rolled	46.96	38.	10.82	1.9	....	....	Mn, 2.24
Benedict Plate	57.	28.	15.	....	....	....	
Back Case Metal	62.	20.	18.	....	....	....	
Bismuth Bronze	45.	21.5	32.5	....	16.	....	Bi, 1.
Bismuth Bronze	53.	20.	10.	....	15.	....	Bi, 1.; Al, 0.1
Bismuth Brass	47.	21.	30.9	....	1.	....	Bi, 1.
Bismuth Brass	52.	12.	30.	....	....	5.	Bi, 1.
Brazing Solder	35.	57.	8.	....	....	....	
Brazing Solder	45.	45.	10.	....	....	....	
Carbondale	66.	16.	18.	....	....	....	
Casting	55.8	23.7	13.4	....	4.	3.5	
Casting	69.9	5.6	19.8	....	....	....	Cd, 4.7
Colorado Metal	57.	18.	25.	....	....	....	
Christofle Metal	(Silver-plated German Silver)						Ag, 2.0
Chromax Bronze	66.7	12.1	15.2	....	....	....	Al, 3.; Cr, 3
Cupping and Milling	58.	21.5	20.	....	....	0.5	
Drawing and Spinning	58.66	29.33	12.	....	....	....	
English	81.3	19.1	19.1	....	....	....	
Eighteen Per Cent	65.	17.	18.	....	....	....	
Electrum	51.61	22.58	25.81	....	....	....	
Fifteen Per Cent	56.66	28.33	15.	....	....	....	
Fourteen Per Cent	60.	26.	14.	....	....	....	
Fourteen Per Cent	56.	28.	14.	....	....	....	
Flat Ware Stock	53.	26.	21.	....	....	....	
Frick's Alloys	55–50	31–30	19–17	....	....	....	
Bluish-Yellow, Hard	55.50	39.00	5.50	....	....	....	
Pale Yellow, Ductile	62.50	31.20	6.30	....	....	....	
Fricke's Silvery	50.00	18.80	31.20	....	....	....	
Fricke's Harder	69.00	30.00	10.00	....	....	....	
German Silvers:							
Best	46.	34.	20.	....	....	....	
Common Formula	55.	25.	20.	....	....	....	
Austrian Tableware (Gersdorf)	50.00	25.00	25.00	....	....	....	
Austrian Tableware (Gersdorf)	55.60	22.20	22.20	....	....	....	
Austrian Malleable (Gersdorf)	60.00	20.00	20.00	....	....	....	
Berlin Alloy	54.	28.	18.	....	....	....	
Richest	52.00	26.00	22.00	....	....	....	
Medium	59.00	30.00	11.00	....	....	....	
Lowest	63.00	31.00	6.00	....	....	....	
Birmingham (Hiorns):							
Extra White Metal	50.	20.	30.	....	....	....	
White Metal	54.	22.	24.	....	....	....	
Arguzoid	48.5	31.	20.5	....	....	....	
Best Best	50.	29.	21.	....	....	....	
Special Firsts	56.	27.	17.	....	....	....	
First Bests	56.	28.	16.	....	....	....	
Seconds	62.	24.	14.	....	....	....	
Thirds	56.	32.	12.	....	....	....	
Special Thirds	56.5	32.5	11.	....	....	....	
Fourths	55.	35.	10.	....	....	....	
Fifths, for Plate	57.	36.	7.	....	....	....	
French Alloy (Arcet)	50.00	31.30	18.70	....	....	....	
French Alloy (Arcet)	50.00	30.00	20.00	....	....	....	
French Alloy (Chaval)	58.30	25.00	16.70	....	....	....	
Russian	56.2	23.36	20.4	....	....	....	
Russian	51.4	22.32	26.22	....	....	....	
Russian	46.1	18.	35.8	....	....	....	

NICKEL SILVER (*Continued*).

	Cu	Zn	Ni	Fe	Sn	Pb	Other Elements
German Silvers (*Continued*)							
Sheffield:							
Common, Yellow	59.30	25.90	14.80	....	....	....	
Silver, White	55.20	24.10	20.70	....	....	....	
Electrum, Bluish	51.60	22.60	25.80	....	....	....	
Hard Alloy	45.70	20.00	31.30	....	....	....	
Key Stock	60.	26.	12.	....	....	2.	
Key Stock	65.	22.	12.	....	....	1.	
Knife Bolsters	68.	16.50	15.	....	....	0.5	
Knife Bolsters	56.	28.	16.	....	....	....	
Maillechort, Paris	66.24	13.42	13.42	3.21	0.22	0.15	
Maillechort, Vienna	66.6	13.6	19.3	0.48	....	....	
Maillechort	65.4	13.4	16.8	3.4	....	....	
Mangan-Neusilber	59.	20.	18.	....	....	....	Mn, 3
Mangan-Neusilber	65.	5.	10.	....	....	....	Mn, 20.
Mangan-Neusilber	72.25	8.75	16.57	....	....	....	Mn, 2.43
Milling	56.	31.	12.	....	....	1.	
Milling	56.5	28.	15.	....	....	0.5	
Milling	56.	27.5	16.	....	....	0.5	
Milling	54.	27.5	18.	....	....	0.5	
Naubuc Knife Stock	58.	16.25	25.	0.75	....	....	
Neogen	58.0	27.	12.	....	2.	....	Bi, 0.5; Al, 0.5
Nickel Bronze	60.	12.	20.	....	8.	....	
Nickel Bronze	47.	....	3.	....	10.	....	PSn, 1.0
Nickel Bronze	47.	21.	30.9	....	1.	....	Bi, 0.1
Nickel Bronze	50.	18.	12.	....	2.	18.	
Nickel Bronze	61.5	10.95	15.35	....	1.88	10.15	
Nickel Brass	50.00	34.9	15.	....	....	....	Al, 0.1
Nickel Bearing	50.	....	25.	....	25.	....	
Nickelin	55.3	13.1	31.07	0.43	....	0.18	
Nickel Oreide	65.50	32.66	2.	....	....	....	
Nickel Oreide	64.	32.	4.	....	....	....	
Nickel Oreide	63.33	31.66	5.	....	....	....	
Nickel Oreide	86.66	6.66	6.66	....	....	....	
Nickel Oreide	63.33	30.66	6.	....	....	....	
Optical Wire	54.	28.	18.	....	....	....	
Optical Wire	55.	27.	18.	....	....	....	
Packfong	40.4	25.4	31.6	2.6	....	....	
Packfong	26.3	36.8	36.8	....	....	....	
Packfong	43.8	15.6	40.6	....	....	....	
Platinoid	54.00	20.40	24.77	0.47	....	0.15	Mn, 15.
Platinoid	60.	24.	14.	....	....	....	W, 1–2
Resistance Wire	56.50	25.50	18.	....	....	....	
Rheotan	52.	18.	25.	5.	....	....	
Rolling	49.	39.	12.	....	....	....	
Seawater Bronze	45.	5.5	32.5	....	16.	....	Bi, 1.
Silvel, Cast	67.93	15.84	6.52	2.22	....	0.48	Mn, 6.8; Al, 0.13
Show-case Metal	58.	24.	18.	....	....	....	
Show-case Metal	59.50	22.50	18.	....	....	....	
Sheffield	57.	24.	19.	....	....	....	
Sheffield	63.34	17.01	19.13	....	....	....	
Sheffield	62.63	26.65	10.85	....	....	0.2	
Sheffield	54.7	37.2	17.1	....	....	....	
Sheffield	57.4	26.5	13.0	....	....	3.0	
Smitter-Lenian	72.	9.75	12.75	2.	2.25	....	Bi, 1.
Spoons, Forks, etc	60.	22.	18.	....	....	....	
Sterlin	68.52	12.84	17.88	....	....	0.76	
Sterline	68.	13.25	18.	0.75	....	....	
Suhler White Copper	40.4	25.4	31.6	....	....	2.6	
Ten Per Cent	56.	34.	10.	....	....	....	

NICKEL SILVER (*Continued*).

	Cu	Zn	Ni	Fe	Sn	Pb	Other Elements
Ten Per Cent	60.	30.	10.	....	....	....	
Ten Per Cent	62.	28.	10.	....	....	....	
Tuc-Tur, Rod	61.2	20.9	17.6	0.3	....	....	
Tuc-Tur, Sheet	58.6	28.5	12.5	0.3	....	....	
Turbine Bushing	61.5	10.95	15.35	....	1.9	10.15	
Tutenag	43.8	40.6	15.6	....	....	....	
Tutenag	45.7	36.96	17.33	....	....	....	
Tutenag	44.	16.	40.	....	....	....	
Toucas	35.75	7.14	28.56	7.14	7.14	7.14	Sb, 7.13
Tungsten Brass	60.	22.	14.	....	....	....	W, 4.
Turning	58.50	29.00	12.00	....	....	0–5	
Turning	65.	22.	12.	....	....	1.	
Twenty Per Cent	53.33	26.66	20.	....	....	....	
Twenty Per Cent	57.	23.	20.	....	....	....	
Twenty Per Cent	62.	18.	20.	....	....	....	
Twenty Per Cent	64.	16.	20.	....	....	....	
Twenty-one Per Cent	57.	22.	21.	....	....	....	
Twenty-one Per Cent	59.	20.	21.	....	....	....	
Thirty Per Cent	46.66	23.33	30.	....	....	....	
Thirty Per Cent	54.	16.	30.	....	....	....	
Victor Metal	49.94	34.27	15.4	0.28	....	....	Al, 0.11
Viennese Sheet	60.	20.	20.	....	....	....	
Viennese Ornaments	55.	25.	20.	....	....	....	
Viennese Tableware	50.	25.	25.	....	....	....	
Wagner's Formula	50.66	19.31	13.18	....	....	....	
Watch-case Bezels	60.	24.	16.	....	....	....	
Watch-case Bezels	63.	21.	16.	....	....	....	
Wessels Silver	51.	17.	32.	....	....	....	
White Copper	70.	18.	12.	....	....	....	
White Alloy	48.8	24.4	24.4	2.4	....	....	
White Alloy	53.0	23.0	22.0	2.0	....	....	

ALUMINUM BRONZES, ETC.

	Cu	Al	Fe	Zn	Ni	Other Elements
Aluminum Brass	63.	3.33	....	33.66	....	
Aluminum Brass	67–71	1.25–3.5	....	31.75–25.5	....	
Aluminum Bronze, Percy	90.	10.	....	....	....	
Aluminum Bronze, Percy	86–89	12.5–7.5	....	....	....	Mn, 0.5–1.5; Pb, 1–2
Aluminum Silver	57.	3.	....	20.	20.	
Aluminum Iron Bronze H	89.43	6.97	3.41	....	....	
Aluminum Iron Bronze R	85.16	6.6	7.52	....	....	Mn, 0.5
Aluminum Iron Bronze S	85.15	9.43	4.74	....	....	Pb, 0.38; P, 0.09
Aluminum Magnesium Bronze	94.5–89.5	5–10	....	....	....	Mg, 0.5
Aluminum Manganese Bronze	89.12	9.6	....	....	....	Mn, 1.2
Aluminum Nickel Bronze	85.	5–10	....	....	10–5	
Aluminum Tin Bronze	85.5	2.5	....	2.	....	Sn, 10.
Aluminum Titanium Bronze	90–89	9–10	1.0	....	....	Ti, trace
Ampco	Bal.	7–11	1–3	....	....	
Cowles Aluminum Bronze	88.4	9.74	0.43	....	....	Si, 1.36
Cowles "A", Special A	89.	11.	....	....	....	
Cowles A 1, 2, 3	80	10.	....	....	....	
Cowles B	92.5	7.5	....	....	....	
Cowles C 1	94.5	5.5	....	....	....	
Cowles C 2, 3	95.	5.	....	....	....	
Cowles D	97.5	2.5	....	....	....	
Cowles E	98.75	1.25	....	....	....	
Cupror	94.2	5.8	....	....	....	

ALUMINUM BRONZES, ETC. *(Continued)*.

	CU	AL	FE	ZN	NI	OTHER ELEMENTS
Dirigold	(See Oranium Bronze)					
French (Fe Ni Mn)	81.5	7.	4.	....	5.5	Mn, 2.
Emperor Brass	60.	20.	....	20.	....	
Heusler's Alloy	66.5	11.1	....	....	....	Mn, 22.4
Heusler's Alloy	68.	10.	....	....	....	Mn, 18.; Pb, 4
Heusler's Alloy, Max	61.	13.	....	....	....	Mn, 26.
Hercules Metal	85.5	2.5	....	2.	....	
Hercules Metal	54.	2.5	7.5	36.	....	
Immadium Bronze	(Manganese Bronze with Aluminum)					
Metaline	30.	25.	10.	....	....	Co, 35.
Navy	85–87	7–9	2.5–4.5	....	....	
Oranium Bronze S	97.	3.	....	....	....	
Oranium Bronze M	95.	5.	....	....	....	
Oranium Bronze MH	91.5	8.5	....	....	....	
Oranium Bronze H	90.	10.	....	....	....	
Oranium Bronze HX	89.	11.	....	....	....	
Oranium Bronze HH	88.5	11.5	....	....	....	
Rakel's Metal	87.5	10.5	....	1.	....	Mn, 1.
Roberts-Austen (Purple Gold)	....	21.5	....	....	....	Au, 78.5
Reichs Bronze	85.15	0.6	7.5	....	....	Mn, 0.5
Secretan	91–95	9–5	....	....	....	Mg, 1.5; P, 0.5
Superbronze	56.8	1.2	1.3	37.5	....	Mn, 3.2
Superbronze	68.9	5.1	2.0	20.9	....	Mn, 3.0
Tensilite	64.	3.1	1.2	29.	....	Mn, 2.5; Sn, 0.2
Tensilite	67.	4.4	....	24.	....	Mn, 3.8
Tetmajer	86.1	10.	0.98	....	....	Si, 2.48
Tetmajer	89.7	7.1	0.72	....	....	Si, 2.72
Tetmajer	93.3	4.6	0.89	....	....	Si, 0.98
Typewriter Metal	57.	3.	....	20.	20.	

COPPER-MANGANESE ALLOYS.

	CU	MN	FE	ZN	SN	NI	OTHER ELEMENTS
Cupro-Manganese	90.	10.	0	....	....	....	
Crotorite	70.	30.	2.	....	....	....	
Resistance, Lunge	86.5	11.7	1.8	....	....	....	
Resistance, Lunge	84.32	13.45	1.9	....	....	....	
Resistance Metal	85.	12.	3.	....	....	....	
Manganese Copper	29.2	51.65	9.68	....	....	....	Al, 6.25
Manganese Copper	56.3	40.9	1.5	....	....	....	Si, 1.1
Manganese Copper	75.	25.	....	....	....	....	
Manganese Copper	75.3	22.4	2.15	....	....	....	
Manganese Copper	85.	10.92	1.83	2.0	....	....	C, 0.26
Manganese Copper	85.55	10.66	2.66	....	0.39	....	Pb, 0.45
Manganese Copper	84.33	10.61	2.31	2.1	0.4	....	Pb, 0.3
Manganese Copper	89.7	8.72	1.54	....	....	....	
Manganese Brass	54.2	4.4	2.4	38.2	....	0.5	
Manganese Brass	55.	4.3	0.7	39.5	....	....	Al, 0.5
Manganese Brass	51.15	4.15	2.25	40.	....	2.2	Al, 0.25
Manganese Brass	53.51	3.24	1.44	38.28	1.22	2.14	
Manganese Brass	55.4	3.2	1.06	39.9	....	....	Al, 0.2
Manganese Brass	60.15	2.34	1.19	34.9	0.94	....	Al, 0.23; Pb, 0.39
Manganese Brass	53.4	1.7	0.	39.	2.66	2.5	Al, 0.2
Manganese Brass	53.5	1.53	2.78	39.	....	2.53	
Manganese Brass	69.5	1.0	....	29.5	....	....	
High Manganese Brass:							
Ponsard's	50.	24.	16.	10.	....	....	
Ponsard's	60.	25.	....	15.	....	....	

COPPER-MANGANESE ALLOYS (*Continued*).

	Cu	Mn	Fe	Zn	Sn	Ni	Other Elements
High Manganese Brass (*Continued*).							
Ponsard's	75.	20.	....	2.	....	....	
Cowles	67.5	18.	....	13.	....	....	Al, 1.; Si, 0.5
Cowles	75.5	16.5	....	8.	....	....	
Cowles	80.	15.	....	5.	....	....	
Rheotan	84.	12.	....	4.	....	....	
Manganese Bronze	82.4	0.6	....	....	17.	....	
Manganese Bronze	85.75	0.25	....	....	14.	....	
Manganese Bronze	86.3	2.7	....	5.	6.	....	
Manganese Nickel Silver	72.5	2.43	....	8.75	....	16.57	
Manganese Nickel Silver	65.	20.	....	5.	....	10.	
Manganese Nickel Silver	60.	20.	....	....	10.	10.	
Manganin	86–84	12.	....	....	....	2–4	
Manganin	84.	4.	....	....	....	12.	
Manganese Nickel	78.3	14.1	....	....	....	7.6	
Manganese Nickel	82.12	15.02	0.6	....	....	2.3	
Manganese Nickel	73.	24.	....	....	....	3.	
Manganese Nickel	70.	25.	....	....	....	5.	
Manganese Nickel	65.	30.	....	....	....	5.	
Manganese Nickel	51.5	31.3	....	....	....	16.2	
Silvel	73.3	12.	1.8	12.1	....	....	Al, 0.25; Pb, 0.51
Silvel	67.9	6.8	2.22	15.8	....	6.5	Al, 0.13; Pb, 0.48
Heusler's Magnetic Alloys	70.	30.	....	....	....	....	Al, 8–14.5
Heusler's Magnetic Alloy, max.	61.	26.	....	....	....	....	Al, 13.
Heusler's Magnetic Alloy	66.5	22.4	....	....	....	....	Al, 11.1
Heusler's Magnetic Alloy	68.	18.	....	....	....	....	Al, 10.; Pb, 4.
Tubes	96.	4.	....	....	....	....	

ALUMINUM ALLOYS

	Al	Cu	Zn	Mn	Mg	Ni	Fe	Si	Other Elements
Acieral:									
Sheet	Bal.	2.3	....	1.5	0.1	....	1.4	....	
Sheet	Bal.	3.7	....	1.0	0.2	....	1.3	....	
Sheet	Bal.	3.8	....	1.0	0.5	....	0.7	....	
Cast	Bal.	6.4	0.4	....	....	0.90	0.1	0.4	
Cast	91.87	5.7	....	....	0.12	0.98	0.94	0.39	
Aero Metal:									
Sheet	Bal.	0.6	....	0.14	2.1	....	1.3	....	
Sheet	Bal.	0.2	....	....	2.9	....	0.3	0.4	
Cast	Bal.	4.2	27.8	....	....	....	0.5	0.5	
Aluminite Cast	Bal.	2.7	23.3	....	....	....	0.4	0.2	
Aluminum Silver	95.00	....	....	....	....	....	....	....	Ag, 5.
Bell Metal	83.00	....	....	10.	....	....	....	....	Cd, 7.
Bourbonnes	48.8	0.25	....	....	....	....	0.33	....	Sn, 50.48
Bersch Bearing	93.	....	....	....	....	7.	....	....	
Duralumin	Bal.	3.5 5.5	....	0.5 0.8	0.5	....	....	....	
Duralumin	Bal.	4.2	....	0.49	0.76	....	0.67	0.34	
Durand's	66.6	....	33.3	....	....	....	....	....	
Die Casting	92. 82.	8. 18.	....	....	....	....	....	....	
Die Casting	86.13	10.17	0.24	0.03	0.32	....	2.81	0.3	
Fletcher and Emperer Bearing	92.2	7.5	....	....	....	....	....	....	Sn, 0.25
Fletcher's Alloy	95.5	3.	....	....	....	....	....	....	Sn, 1.; Sb, 0.5; PSn, 5
Hard Aluminum	77.	....	11.5	....	4.5	....	....	....	

ALUMINUM ALLOYS (*Continued*).

	AL	CU	ZN	MN	MG	NI	FE	SI	OTHER ELEMENTS
Huron:									
Castings A-5	Bal.	6.6	....	....	0.5	1.25	....	....	Co, 0.25 and (Mn Sn Cd, 0.5)
Rolled A	Bal.	3.5	....	0.6	0.5	....	....	....	Cr, 0.1
Rolled B	Bal.	4.0	....	0.6	0.5	....	....	....	Cr, 0.1
Rolled D	Bal.	4.0	....	....	0.5	....	....	....	Cr, 0.6
Ingots:									
Casting 11	88.85	6.6	2.3	1.	....	1.25	....	....	
Casting 12	92.	8.	....	....	....	....	....	....	
Casting 21	90.	10.	....	....	....	....	....	....	
Casting 22	83.7	6.3	5.	....	....	....	....	....	Sn, 5.
Casting 31	80.5	3.	16.	5.	....	....	....	....	
Casting 32	64.	....	36.	....	....	....	....	....	
Casting 33	81.	....	19.	....	....	....	....	....	
Casting 34	78.	....	22.	....	....	....	....	....	
Rolling 3.5	98.5	....	....	1.5	....	....	....	....	
Rolling 5.5	94.5	2.	2.	1.5	....	....	....	....	
Rolling 8.5	66.6	....	33.3	....	....	....	....	....	
Krupp (Grosmann)									
Bearing	87.	8.	....	....	....	....	....	....	Sn, 5.
L-5	Bal.	2.5–3.0	12.5–14.5	....	....	....	....	....	
Liberty Piston	76.6	1.06	21.3	....	....	....	0.47	....	Pb, 0.33; Sn, 0.12
Lynite:									
146	Bal.	7.00–8.5	....	....	....	....	....	....	
122	Bal.	9.25–10.75	....	....	....	....	....	....	
109	Bal.	11.5–13.5	....	....	....	....	....	....	
Crank Case	Bal.	7.8	1.5	....	....	....	1.25	....	
Body Alloy	Bal.	5.	....	....	....	....	....	....	
Piston	89.	11.	....	....	0.5	....	....	....	
Piston	95.3	2.14	....	0.07	1.5	....	0.76	0.23	
Mach's	Bal.	....	....	....	2–10	....	....	....	
Magnalium:									
Cast x	Bal.	1.76	....	....	1.6	1.16	....	....	
Cast y	Bal.	1.75	....	....	1.5	....	....	....	Sn and Pb
Cast z	Bal.	0.21	....	....	1.58	....	....	....	Sn, 3.15; Pb, 0.7
Cast	85.00	....	....	....	15.00	....	....	....	
Sheet	95.	....	....	....	5.	....	....	....	
	Bal.	....	1–20	....	1–10	....	....	....	
Magnalite	Bal.	2.	....	....	2.	2.	....	....	
Magnalite	Bal.	2.5	0.5	....	1.3	1.5	....	....	
Magnalite	93.09	2.19	....	....	1.54	1.45	1.10	0.61	
Magnalite	94.27	2.47	0.13	....	1.17	0.65	0.69	0.59	
Magnalite	93.5	2.61	....	....	1.37	1.72	0.86	0.37	Sn, 0.17
Magnalite	93.9	2.4	....	....	1.56	1.19	0.47	....	
Magnalite	93.2	2.44	....	....	1.38	1.25	1.35	0.37	
Manhardts	83.33	6.24	....	....	0.05	....	....	....	Sn, 10.; P, 0.07
Maluminum	Bal.	6.4	4.8	0.1	....	....	1.4	0.2	Pb, 0.15
McKinney:									
Cast	96.	2.	....	1.5	....	....	....	....	
Forging, Soft	96.5	2.	....	1.0	....	....	....	....	
Forging, Hard	94.5	3.	....	2.	....	....	....	....	
McAdamite	....	3.1	12–18	....	0.2	....	....	....	
McAdams, W. A.	68.5	7.7	23.1	....	.....	0.63	....	....	
McAdams, W. A.	60.	5.	20.	....	....	....	....	....	Ag, 16.5
McAdams, W. A.	70.	3.	26.	....	....	....	....	....	Ag, 1.
McAdams, W. A.	70.	3.	22.	....	....	....	....	....	Sb, 5.
McAdams, W. A.	100.	5.	....	....	....	....	....	....	Ag, 2.
McAdams, W. A.	80.	....	....	....	....	....	....	....	Sn, 8.; Cd, 8.; Ag, 4.
McAdams, W. A.	82.	12.	....	....	....	....	....	....	Cd, 5.; Ag, 1

ALUMINUM ALLOYS *(Continued)*.

	Al	Cu	Zn	Mn	Mg	Ni	Fe	Si	Other Elements
McLure	Bal.	8.2	....	0.2	....	....	0.9	0.3	Sn, 5–6
Metalline	25.	30.	....	...	....	....	10.	....	Co, 35.
Meteorite	Bal.	....	1–2	....	....	....	....	....	P, 1–4
Mock Silver	84.2	5.5	....	....	....	....	....	....	Sn, 10.2; P, 0.1
Murman's	92.	....	4.4	....	3.6	....	....	....	
Murman's	72.	....	14.5	....	13.5	....	....	....	
Navy	Bal.	1.5	....	0.9	....	0.4	0.4	0.3	
Partinium	Bal.	0.64	....	....	....	....	....	....	Sb, 2.4; Sn, 0.16; W, 0.8
Partinium	88.5	7.4	1.7	....	....	....	1.3	1.1	
Pistons	93.3	3.39	....	....	1.39	....	1.46	0.45	
Pistons	93.5	2.45	0.28	....	1.47	1.47	0.4	0.4	
Platinum Substitute	23.6	....	....	....	....	0.72	....	....	Bi, 3.7; Au, 0.7
Romanium	Bal.	0.25	....	....	....	1.75	....	....	Sb, 0.25; Sn, 0.15; W, 0.17
Rosein	30.	....	....	....	....	40.	....	....	Sn, 20.; Ag, 10.
Rosenhain and Archutt Forging	72.	3.	25.	....	....	....	....	....	
Sibley Alloy	67.	....	33.	....	....	....	....	....	
Susini	Bal.	1.5	0.5	1–3	....	....	....	....	
Susini	Bal.	2.5	1.0	1–5	....	....	....	....	
Susini	Bal.	4.5	1.5	2–8	....	....	....	....	
T. Metal	Bal.	0.1	....	....	3.8	....	0.5	0.5	
Tiers Argent	66.	....	....	....	....	....	....	....	Ag, 33.
Verilite	Bal.	2.5	....	0.3	....	....	0.7	0.4	
Wolframium	98.	0.36	....	....	....	....	0.22	....	Sb, 1.4; W, 0.05
Wolframium	98.	0.375	....	....	....	....	....	....	Sb, 1.44; Sn, 1; W, 0.04
W. 0.33	Bal.	14.	....	1.	....	....	....	....	
Zeppelin Alloys:									
Rod	94.58	4.16	....	0.62	....	....	0.42	0.52	
Braces	99.1	0.06	0.13	....	....	....	0.38	0.36	
Channels	88.68	0.7	9.1	0.45	....	....	0.43	0.49	Sn, 0.15
Angles	90.27	0.73	7.8	0.27	....	....	0.45	0.37	Sn, 0.11
Zimalium	93.5	....	2.8	....	3.7	....	....	....	
Zimalium	91.	....	4.5	....	4.5	....	....	....	
Zimalium	88.5	....	4.4	....	7.1	....	....	....	
Zimalium	74.	....	14.8	....	11.2	....	....	....	
Zisium	83.	1.	15.	....	....	....	....	....	Sn, 1.
Zisium	82.	3.	15.	....	....	....	....	....	
Ziskon	60.	....	40.	....	....	....	....	....	
Al-Cu, Strongest	Bal.	3.75	....	....	....	....	....	....	
Al-Cu	91.66	7.16	....	....	....	....	0.85	0.33	
Al-Cu	91.62	7.57	0.1	0.07	....	....	0.43	0.22	
Al-Cu-Ni	Bal.	2.	....	....	....	5.25	....	....	
Al-Cu-Ni	Bal.	4.1	....	....	....	1.1	....	....	
Al-Cu-Zn Strong:									
Cast	80.	5.	15.	....	....	....	....	....	
Forged	75.	3.	22.	....	....	....	....	....	
Centrifugal Cast	80.	3.	17.	....	....	....	....	....	
Ingot	82.7	3.15	12.8	0.39	....	....	0.48	0.19	Pb, 0.19; Sn, 0.12
Ingot	82.8	5.52	9.9	0.18	....	....	0.81	....	Pb, 0.3; Sn, 0.27
Casting	83.55	4.87	11.1	0.06	....	....	0.19	0.27	
Al-Cu-Mg Casting	93.6	3.61	....	....	2.23	....	0.31	0.28	
Al-Cu-Mg Casting	93.	3.65	....	....	2.25	....	0.60	0.38	
Al-Cu-Mg Casting	91.9	3.37	....	0.55	3.5	....	0.38	0.29	
Al-Cu-Mg Casting	95.5	4.	....	....	0.5	....	....	....	
Al-Ni-Ti	97.6	....	....	....	....	2.0	....	....	Ti, 0.4

ALUMINUM ALLOYS (*Continued*).

	AL	CU	ZN	MN	MG	NI	FE	SI	OTHER ELEMENTS
Al-Ni-Zn.........	85.	....	5.	....	....	10.	....	....	
Va Alloy.........	80.2	5.01	13.7	....	....	....	0.72	....	V, 0.2
W Alloy.........	82.1	12.32	4.5	....	....	....	....	....	W, 1.0
Alloys Research Committee:									
"Y" Casting...	82.5	4.	....	....	1.5	2.	....	....	
"A" Forging...	77.	3.	20.	....	....	....	....	....	
"E" Rolling...	76.	2.5	20.	0.5	0.5	....	0.2	0.2	

TIN BASE ALLOYS.

	SN	SB	CU	PB	OTHER ELEMENTS
Algiers Metal	94.5	0.5	5.	....	
Algiers Metal	90.	10.	....	....	
Algiers Metal	75.	25.	....	....	
Ashberry Metal	80.	14.	2.	....	Zn, 1.
Ashberry Metal	79.	15.	3.	....	Zn, 2.
Ashberry Metal, Brittania	77.8	19.4	2.8	....	
Ashberry Metal, Brittania	77.9	19.4	....	....	Zn, 2.8
Argentin	85.	14.5	0.5	....	
Aluminum Solder	85–50	....	....	....	Zn, 15–50
Burgess	76.	....	....	....	Zn, 21.; Al, 3.
Frismuth	67.	....	....	27.	Al, 3.
Grimm's	69.1	....	....	28.8	Zn, 1.44; Ag, 0.72
Grimm's	50.	....	....	25.	Zn, 25.
Aluminum, Wegner and Guhr's	80.	....	....	....	Zn, 20.
Aluminum, Wilmotts	86.	....	....	....	Bi, 14.
Aluminum, Various	Bal.	....	....	....	Zn, 8–15; Al, 5–12.
	50.	....	....	33.3	Zn, 66.6
	47.5	....	....	47.5	Ca, 5.
	49.5	3.43	1.1	26.06	Zn, 20.31
	85.	....	....	....	Al, 10.; P Sn, 5.
Babbitts, Original	89.	7.3	3.7	....	
Babbitts, Hard	83.3	8.3	8.4	....	
Bearing:					
Navy	89.	7.3	3.7	....	
Navy	91.	4.5	4.5	....	
Prussian	91.	6.	3.	....	
Prussian	90.	6.	4.	....	
Russian Railroad	90.	8.	2.	....	
Automobile, American	89.	7.	4.	....	
Automobile, American	89.3	8.9	1.8	....	
Automobile, American	88.9	7.4	3.7	....	
Automobile, American	87.	7.	6.	....	
Heavy	85.	7.5	7.5	....	
French Car	83.3	11.1	5.5	....	
German Railroad	83.	11.	6.	....	
Valve Rods, etc	82.	10.	8.	....	
French Railroad	82.	12.	6.	....	
Piston	81.	12.5	6.5	....	
Swiss Railroad	80.	10.	10.	....	
English	76.7	18.5	7.8	....	
German	76.	17.	7.	....	
Prussian	74.	15.	11.	10.6	Zn, 0.18; Fe, 0.22
Prussian	73.	18.	9.	....	
Prussian	72.	26.	2.	....	
(Kamarsch)	71.4	7.2	21.4	....	
Valve Packing	71.	24.	5.	....	

TIN BASE ALLOYS *(Continued)*.

	Sn	Sb	Cu	Pb	Other Elements
Bearing *(Continued)*.					
German	70.8	15.1	4.9	9.2	
(Kamarsch)	70.7	19.7	9.5	....	
G. W. R. England	67.	11.	22.	....	
French Railroad	67.	22.	11.	....	
English Railroad	90.	7.	3.	....	
German Ludenscheidt	71.8	24.3	3.85	....	
Brittania:					
English	94.	5.	1.	....	
English	90.	6.	2.	....	Bi, 2.
English	90.	7.	3.	....	
English	85.5	9.7	1.8	....	Zn, 3.
Cast	90.6	9.2	0.2	....	
Cast	85.5	10.5	1.	....	Zn, 3.0
Cast Tutania	91.4	....	0.7	7.62	Zn, 0.25
Cast Tutania	92.35	4.65	2.45	0.32	
Birmingham I	90.57	9.38	0.03	....	
Birmingham II	85.5	10.5	1.	....	Zn, 3.0
Sheet	91.5	7.1	1.4	....	
Sheet	90.6	7.8	1.5	....	
Spinning	93.7	3.75	2.6	....	
Spoons	88.4	8.7	2.9	....	
Spoons	85.5	14.4	0.15	....	
Spoons	84.7	5.0	3.7	....	Bi, 4.9; Zn, 1.
Spoons	88.42	8.68	2.8	....	
Spoons	85.42	14.42	0.15	....	
Spoons	84.46	5.62	3.68	....	Zn, 1.53; Bi, 4.88
Plate, Hard Spelter	90.62	7.81	1.46	....	
Plate, Birmingham	91.46	7.12	1.4	....	
Plate, Tutania	90.	....	2.7	6.0	Zn, 1.3
Plate, Deutsch (Ludenscheidt)	71.85	24.26	3.85	....	
German	84.	9.	2.	....	Zn, 5.
German	81.9	16.3	1.8	....	
German	70.82	15.10	4.91	9.21	
German, Various, Turn	93.65	3.75	2.63	....	
German, Queen's Metal	88.52	7.10	3.48	....	
Blatt-Silver	91.1	....	....	0.35	Zn, 8.25; Fe, 0.23
Bushing, Russian	72.2	....	1.3	....	Zn, 26.5
Clichier Metal	48.	10.5	....	32.5	Bi, 9.
Clichier Metal	80.	....	....	5.	Bi, 15.
Deurance Metal (Locomotive)	33.3	44.5	22.2	....	
Dudley Antifriction	98.13	....	1.6	0.25	
Fahrig Antifriction	90.	....	10.	....	
Gilding Foil	97.6	....	2.16	....	Fe, 0.11
Hard Head	90.	8.	2.	....	
Hammonia Metal	64.5	....	3.25	....	Zn, 32.25
Hoyles Metal	46.	12.	....	42.	
Husmann Metal	73.6	11.	4.	10.6	Zn, 0.18; Fe, 0.22
Jacoby Metal	85.	10.	5.	....	
Kamarsch Bearing	85.	5.	3.6	....	Bi, 1.6; Zn, 1.4
Minofor (Brittania)	68.5	18.2	3.3	....	Zn, 10.
Minofor	66.	20.	4.	....	Zn, 9.
Navy Bearing	89.	7.3	3.7	....	
Navy Bearing, Hard	80	15	5	....	
Parsons White Brass	60.	....	5.	....	Zn, 35.
Parsons White Brass	81.	11.	4.5	3.5	
Parsons White Brass	76.	6.	5.	13.	
Pewter	80.	....	....	20.	
Pewter	73.5	5.5	1.	20.	
Pewter	88.42	7.16	3.54	....	Zn, 0.88

TIN BASE ALLOYS (*Continued*).

	Sn	Sb	Cu	Pb	Other Elements
Pewter	89.3	7.6	1.8	1.8	
Pewter	87.2	5.7	1.6	11.5	
Pewter	89.3	7.6	1.8	1.8	
Pewter	84.7	1.7	6.8	....	Bi, 6.
Phosphor Tin	95.	....	....	....	P, 5.0
Phosphor Tin	90.	....	....	....	P, 10.
Plastic Metal	80.5	8.6	9.5	....	Fe, 1.4
Poterie d'Etain	90.	9.	1.	....	
Prince's Metal	84.75	15.25	....	....	
Queen's Metal	50.5	16.5	....	16.5	Zn, 12.5
Queen's Metal	87.	8.5	3.5	....	Zn, 1.
Queen's Metal	73.36	8.88	....	8.8	Zn, 8.88
Queen's Metal	88.5	7.1	3.5	....	Zn, 0.9
Queen's Metal	88.5	7.	3.5	....	Bi, 1.0
Ships Nail Alloy	50.	17.	....	33.	
Silver Foil	90.	....	....	....	Zn, 10.
Silver Foil	97.5	....	2.5	....	
Stanniol	96.2	....	1.	2.4	Ni, 0.3; Fe, 0.1
Tinfoil	87.5	0.5	4.	8.	
Tourun Leonard's Metal	90.	....	10.	....	
Trabuk Metal	87.5	5.	....	....	Ni, 5.5; Bi, 2.
Tinsel	60.4	....	....	39.6	
Tutania, Cast	91.4	....	0.7	7.62	Zn, 0.25
Tutania, Cast	92.4	4.6	2.5	0.32	Fe, 0.13
Tutania, English	80.	16.	2.7	....	Zn, 1.3
Tutania, Plate	90.	....	2.7	6.0	Zn, 1.3
White Metal, Hanover	86.8	7.6	5.6	....	
White Metal, Dutch	81.5	8.8	9.6	....	

LEAD BASE ALLOYS.

	Pb	Sn	Sb	Cu	Other Elements
Accumulator Metal (Condenser Foil)	90.	9.25	0.75	....	
Aluminum Solder, Frismuth	27.	67.	....	....	Al, 3.
Antifriction	60.	....	20.	....	Zn, 20.
Antifriction	88.	....	12.	....	
Antifriction	84.	....	16.	....	
Antifriction	78.8	....	19.6	....	Zn 1.
Antifriction	77.	10.	12.5	0.5	
Antifriction	77.	8.	14.	1.	
Battery Plates	94.	....	6.	....	
Bearing	80.5	11.6	7.4	0.5	
Bearing (Katzenstein)	77.6	7.3	16.8	0.4	
Bearing	73.0	8.5	18.0	0.4	
Bearing	68.0	9.6	20.5	1.6	
Bearing	71.	7.7	18.5	2.	
Bearing	62.5	26.2	10.	1.3	
Bearing	61.0	25.0	13.0	1.0	
Bearing	48.	40.	10.	2.	
Bearing (American)	46.	36.5	16.5	1.0	
Bearing	40.	42.	16.	2.	
Bearing	37.	50.	12.	1.	
Bearing	25.5	61.	10.5	2.8	
Bearing	11.8	74.	9.5	4.7	
Bearing	10.	75.	12.	3.	
Bearing	86.	1.	13.	....	
Bearing	83.3	8.3	8.3	8.	
Bearing	82.	2.	16.	....	
Bearing	80.	10.	10.	....	

LEAD BASE ALLOYS (*Continued*).

	PB	SN	SB	CU	OTHER ELEMENTS
Bearing Compagnie de l'Est	80.	12.	8.	....	
Bearing	80.	5.	15.	....	
Bearing	76.	7.	17.	....	
Bearing, American Railroad	73.5	8.	18.5	....	
Bearing, French Railroad	70.	20.	10.	....	
Bearing, Paris-Lyon-Mediterranean Railroad	70.	10.	20.	....	
Bearing, American Railroad	68.	21.	11.	....	
Bearing, Graphite Metal	68.	15.	17.	....	
Bearing	62.	27.	10.	....	
Bearing	60.	20.	20.	....	
Bearing, Chemin de fer de l'est Franc	42.	42.	16.	....	
Bearing	40.	45.	15.	....	
Bearing, Italian Railroad	37.	38.	25.	....	
Bearing	10.	75.	15.	....	
Capsule Metal	92.	8.	....	....	
Clichier Metal	46.	33.	....	....	Cd, 21.
Clichier Metal	50.	36.	....	....	Cd, 14.
Clichier Metal	32.5	48.	10.5	....	Bi, 9.
Clichier Metal	5.	80.	....	....	Bi, 15.
Electrotype Metal	93.	3.	4.	....	
English Linotype	83.	5.	12.	....	
English Stereotype	82.5	4.5	13.	....	
Frary Metal	98.	....	....	....	Ba Ca 2.
Fahlun Brilliants	40.	60.	....	....	
Foil-Lead (Calin)	86.5	12.5	....	1.0	
French Auto	75.	10.	15.	....	
For Small Castings	5.	75.	20.	....	
Glievor Bearing	76.5	8.	14.	....	Fe, 1.5
"Glyco"	80.5	4.5	14.5	....	As, 0.5
Hard Lead	80.	46.	12.	0.5	
Hoyle's Metal	42.	46.	12.	....	
Jacana Metal	70.	10.	20.	....	
Locomotive Bushing	65.6	8.8	15.4	....	
Linotype Metal	85.	3.	12.	....	
Mackenzie Metal	70.	13.	17.	....	
"Magnolia"	78.	6.	16.	....	
"Magnolia"	79.75	5.	15.	....	Bi, 0.25
Marine Babbitt	72.	21.	7.	....	
Metallic Packing	82.25	4.75	....	....	
Metallic Packing, Compagnie d'Orleans	76.	14.	10.	....	
Mystic Metal	88.7	....	10.8	....	Bi, 0.1
Non-pareil	78.35	4.95	16.7	....	
Noheet	98.41	0.08	0.11	....	Na, 1.4
Pewter	11.5	87.2	5.7	1.6	
Pewter	20.	80.	....	....	
Piston Packing, Compagnie de Nord	73.	12.	15.	....	
Shot Lead	99.8	....	....	....	As, 0.2
Solder	60.	39.	1.	....	
Plumbers	66.6	33.3	....	....	
Half and Half	50.	50.	....	....	
Tinman's	33.3	66.6	....	....	
Stereotype Metal	82.	6.	12.	....	
Stereotype Metal	82.	3.2	14.8	....	
Stereotype Metal	76.	4.	20.	....	
Stereotype Metal	70.	7.	23.	....	
Stereotype Metal	67.	17.	18.	....	
Stereotype Metal	35.	60.	5.	....	
Tandem	77.7	5.9	16.8	....	
Tea Lead	98.	2.	....	....	
Terne Metal	88.25	18.	1.75	....	

LEAD BASE ALLOYS *(Continued)*.

	PB	SN	SB	CU	OTHER ELEMENTS
Type Metal	70.	10.	18.	2.0	
English, Old	69.2	9.1	19.5	1.7	
English	63.2	12.	24.	0.8	
English	60.5	14.5	24.2	0.8	
Krupp	59.6	12.	18.	4.7	Ni, 4.7; Bi, 1.
English	58.	15.	26.	1.	
English	77.5	6.5	16.	....	
German	75.	2.	23.	....	
German	60.	35.	5.	....	
German	60.	34.6	5.4	....	
German	60.	15.	25.	....	
Common	60.	10.	30.	....	
Common	55.5	40.	4.5	....	
Best	50.	25.	25.	....	
French	55.	22.	23.	....	
French	55.	15.	30.	....	
Ulco	98.5	....	....	....	Ba Ca, 1.5
White	77.	5.	15.	2.3	
White	33.	53.	10.6	2.4	Zn, 1
White	33.9	49.1	13.6	3.3	

ZINC BASE ALLOYS.

	ZN	CU	SN	SB	PB	OTHER ELEMENTS
Aluminum Solder, Frismuth	47.5	5.5	31.5	....	....	Al, 10.5; Ag, 5.5
Aluminum Solder, Frismuth	47.4	5.3	36.8	....	....	Al, 10.5
Aluminum Solder	30.	....	65.	....	....	Bi, 5.
Aluminum Solder	80.	8.	....	....	....	Al, 12.
Aluminum Solder	57.	....	....	....	....	Cd, 43.
Aluminum Solder, Mourey	94.	2.	....	....	....	Al, 4.
Aluminum Solder, Mourey	80.	8.	....	....	....	Al, 12.
Aluminum Solder, Bourbouse	81.82	....	....	....	....	Al, 18.18
Aluminum Solder, Cornande and Cruiys	52.	....	30.	....	....	Al, 17.5; Ni, 0.5
Aluminum Solder, Richards	25.	....	71.5	....	....	Al, 3.5
Battery Plates	63.4	3.2	21.3	....	12.	
Babbitt Metal	69.	5.	26.	3.	5.	
Bearing, Hard	90.	7.	1.5	1.5	....	
Bearing	88.	8.	2.	2.	....	
Bearing	85.	5.	10.	....	....	
Bearing	77.	5.5	17.5	....	....	
Bearing, English	67.7	7.4	14.9	....	....	
Bearing	66.5	4.2	29.3	....	....	
Bearing	55.	0.55	22.7	....	....	Al, 20.; Pb, 1.25
Biddery	90.2	6.3	0.8	....	2.6	
Biddery Henie's	84.3	11.4	1.4	....	2.9	
Birmingham, Platina	79.4	20.25	....	....	....	Fe, 0.33
Brittania, Cast	48.	3.	48.	1.	1.	
Button	80.	20.	....	....	....	
Cook's Alloy	31.5	....	....	68.5	....	(Zn, 43.; Sb, 57.)
Dunnlevic and Jones	52.	1.6	46.	0.4	....	
Dunnlevic and Jones Antifriction	20.	....	....	20.	60.	
Dunnlevic and Jones Antifriction	85.	5.	....	10.	....	
Dunnlevic and Jones, Russian	80.	8.	....	10.	....	
Ehrhardt's Metal	89.	4.	4.	....	3.	
Ehrhardt's Type	89.	3.	6.	....	2.	
English White Metal	76.2	5.6	17.5	....	....	
Fenton's Alloy	80.	6.	14.	....	....	
Fenton's Alloy	80.	8.5	....	14.5	....	
Glievor Bearing	73.5	4.4	6.7	9.	5.	Cd, 1.4

ZINC BASE ALLOYS *(Continued)*.

	Zn	Cu	Sn	Sb	Pb	Other Elements
Hamilton Metal	93.4	3.5	....	1.5	3.1	Phos. Sn, 5.
Heavy Axle	47.	1.	38.	6.	4.	
Hammonia Metal	32.25	3.25	64.5	....	....	
Iridium	77.25	1.12	21.63	Trace	....	
Iridium	83.00	1.25	15.75	Trace	....	
Kemlet	67	9	....	....	....	Al, 15.
Kneiss Metal	50.	....	25.	....	25.	
Kneiss Metal	40.	3.	15.	....	42.	
Leddel Alloy	90.	5.	....	....	....	Al, 5.
Ledebur's Bearing	85.	5.	....	10.	....	
Ledebur's Bearing	77.	5.5	17.5	....	....	
Leddel Bearing	87.5	6.25	....	....	....	Al, 6.25
Lumen	86.	10.	....	....	....	Al, 4.
Lumen	85.	10.	....	....	....	Al, 5.
"Hartzink"	91.9	0.13	....	....	2.4	Fe, 5.3
Parsons White Brass	30.	5.	65.	....	....	
Pierrot Metal, Beugnot	83.3	8.3	7.6	3.5	3.	
Propeller Bushing	69.	5.	19.	7.	....	
Pump Cocks	72.	7.	21.	....	....	
Russian, Packing	98.5	....	0.98	....	0.32	Fe, 0.16
Russian	26.5	1.3	72.2	....	....	
Salge Metal	85.5	4.	9.9	....	1.1	
Schomberg-Bearing	59.4	0.38	39.8	....	0.21	Fe, 0.15
Silver Leaf	8.25	....	91.	....	0.35	
Silver Metal	66.5	....	....	....	....	Ag, 33.5
Siemens Halske	48.	....	....	5.	....	Cd, 47.
Siemens Halske, Automobile	47.5	....	....	5.	....	Cd, 47.5
Sorel's Alloy	98.	1.	....	....	....	Fe, 1.
Sorel's Alloy	88.	10.	....	....	....	Fe, 10.
Spiauter (Hard Zinc)	90.	2.	....	8.	....	
Vaucher's Alloy	75.	....	18.	2.5	4.5	
Zelco	73	2	....	....	....	Al, 15.0

FUSIBLE METALS.

	Bi	Sn	Pb	Cd	Other Elements	Temperature of Fusion
Anatomical Alloy	53.5	19.	17.	....	Hg, 10.5	60° C.
Bismuth Solder	40.	20.	40.	....		
Bismuth Solder	33.3	33.3	33.3	....		
Bismuth Solder	27.5	45.	27.5	....		
Bismuth Solder	25.	50.	25.	....		
D'Arcet	50.	25.	25.	....		
Eutectic	52.5	15.5	32.	....		96° C.
Eutectic	49.5	13.1	27.3	10.1		70–74° C.
Eutectic	51.6	....	40.2	8.1		91.5° C.
Eutectic	54.	26.	....	20.		103° C.
Eutectic	....	50.	32.	18.		145° C.
Fusible Tea Spoons	44.5	16.5	30.	....	Hg, 5–10	
Guthrie's	47.38	19.97	19.36	13.29		
Lictenberg	50.	20.	30.	....		
Lipowitz	50.	13.3	26.7	10.		
Newton's	50.	18.75	31.25	....		
Onion's	50.	20.	30.	....		
Rose's	50.	22.	28.	....		
Rose's	35.	30.	35.	....		
Wood's	50.	12.5	25.	12.5		

GOLD ALLOYS.

	Au	Ag	Cu	Other Elements
Standard Gold, British	91.66	....	8.33	
Standard Gold, U. S	90.	....	10.	
22 Carat	91.66	4.166	4.166	
22 Carat Dental, Dark	91.57	4.99	3.44	
22 Carat Dental, Light	91.57	8.43	....	
20 Carat	83.33	8.33	8.33	
20 Carat	83.20	10.81	5.99	
18 Carat	75.0	10.4	14.6	
18 Carat	75.00	12.00	13.00	
18 Carat	75.00	14.6	10.4	
18 Carat Dental	74.88	19.13	5.99	
18 Carat Special	75.00	20.00	5.00	
16 Carat	66.6	6.6	26.6	
16 Carat	66.66	11.12	22.22	
16 Carat	66.6	19.4	13.8	
16 Carat	66.45	25.57	7.98	
15 Carat	62.49	11.01	13.25	
14 Carat	58.3	4.16	37.5	
14 Carat Regular	58.33	13.33	28.34	
14 Carat Spring	58.33	16.00	25.67	
14 Carat	58.3	25.	16.6	
14 Carat Special	58.33	27.77	13.90	
14 Carat Dental	58.03	30.03	11.94	
12 Carat	50.00	14.58	35.42	
10 Carat Regular	41.66	12.34	46.00	
10 Carat	41.6	16.6	41.6	
10 Carat Spring	41.66	20.00	38.34	
8 Carat	33.30	20.00	46.70	
Yellow Gold	53.	25.	22.	
Red Gold	75.	....	25.	
Dark Red Gold	50.	....	50.	
Pale Yellow Gold	91.6	8.3	....	
Pale Yellow Gold	91.6	....	....	Fe, 8.3
Green Gold	75.	25.	....	
Green Gold	75.	16.6	....	Cd, 8.3
Green Gold	74.6	11.4	9.7	Cd, 4.3
Green Gold	75.	12.5	....	Cd, 12.5
Grey Gold	85.7	8.6	....	Fe, 5.7
Grey Gold	83.3	....	....	Fe, 16.6
Blue Gold	75.	....	....	Fe, 25.
White Gold	90.	....	....	Pd, 10
Palladium Gold	90.	....	....	Pd, 10
White Gold	75–85	....	....	Ni, 10-8; Zn. 2-9
Gold Solders:				
18 Carat	75.	13.	12.	
18 Carat	62.5	31.25	6.25	
16 Carat	75.	16.6	8.3	
14 Carat	50.	33.3	16.6	
12 Carat	47.8	29.	17.1	Brass, 6.1
10 Carat	41.2	37.	21.2	Brass, 0.6
9 Carat	25.	50.	25.	
8 Carat	40.	36.6	23.4	
Best	62.5	22.5	15.	
Easy Melt	54.5	31.75	13.75	
Very Easy Melt	11.5	54.5	28.5	Zn, 5.5

SILVER ALLOYS.

	Ag	Cu	Zn	Sn	Other Elements
Sterling Silver	92.5	7.5	....	....	
Rupee	91.6	8.3	....	....	
Standard	90.	10.	....	....	
Silver Solders:					
Hard	80.	13.2	6.8	....	
Sterling	80.	2.5	17.5	....	
Medium	75.	20.	5.	....	
Medium	70.	22.5	7.5	....	
Enamel	66.7	33.3	....	....	
Pure Silver	72.	28.	....	....	
French	66.	23.3	10.	....	
Plate	64.5	22.5	13.	....	
Common	62.5	30.	7.5	....	
Chain	62.5	31.2	6.2	....	
Chain	63.5	20.9	16.6	....	
Quick	62.5	20.9	10.4	6.2	
Quick	56.9	27.7	11.5	3.8	
Bureau of Standards	40.	14.	6.	40.	
Argent Francais (Roulz)	40.	35.	....	....	Ni, 25.
Argent Francais (Roulz)	33.	40.	....	....	Ni,,27.
Argent Francais (Roulz)	20.	50.	....	....	Ni, 30.
Argent Francais (Odessa)	33.25	42.5	15.75	....	Ni, 8.5
Argent Francais, Mousset's Silver	27.5	59.5	9.5	....	Ni, 3.5
Proplatinum	23.57	....	....	....	Ni,72.; Bi,3.72; Au,0.71

PLATINUM, ETC.

	Pt	Au	Ag	Other Elements
Thermo-couples	90.	....	....	Ir, 10.
Thermo-couples	90.	....	....	Rh, 10.
Solder	27.	....	73.	
Resistance	33.3	....	66.6	
Platine-au-titre	17–35	....	83–65	
Platinum-Gold:				
White	40.	60.	....	
Almost White	30.	70.	....	
Almost White	58.3	16.6	25.	
Cooper's Gold	18.75	....	....	Cu, 81.25
Cooper's Gold	29.17	....	....	Cu, 66.6; Zn, 4.15
Cooper's Pen Metal	50.	....	37.5	Cu, 12.5
Cooper's Pen Metal	....	25.	25.	Cu, 50.
Cooper's Mirror	9.5	....	....	Cu, 58.; Sn, 27.5; Zn, 3.5; As, 1.5
Palladium Gold	....	31.	19.	Pd, 10.35; Cu, 39.65
Platinum Substitutes:				
Palau	....	80.	....	Pd, 20.
	20.	....	....	Ni, 60.; Pd, 10.; V, 10.
Cooper's	25.	....	70.	Ni, 5.
Cooper's	....	....	70.	Co, 5.; Pd, 25.
Electrical	7.5	67.5	25.	
Electrical	5.	70.	25.	
Electrical	....	70.	25.	Ni, 5.
Proplatinum	....	0.75	23.5	Ni, 72.; Bi, 3.75

RESISTANCE ALLOYS.

	Ni	Cr	Fe	Mn	Cu	Zn	Other Elements
Advance	44.3	....	0.5	1.15	53.9	....	
Argentan	26.	....	1.	....	56.	18.	
Calido	64.	8.	25.	3.	....	....	

RESISTANCE ALLOYS (*Continued*).

	NI	CR	FE	MN	CU	ZN	OTHER ELEMENTS
Calorite	65.	12.	15.	8.	....	....	
Calorite	65.	12.	23.	....	....	....	
Chromel A	80.	20.	....	....	....	....	
Chromel B	85.	15.	....	....	....	....	
Chromel C	64.	15.	25.	....	....	....	
Climax	24.4	....	73.	2.6	....	....	
Comet	30.4	2.2	66.9	0.8	0.4	....	
Constantin	46.	....	....	....	54.	....	
Constantin	43.9	....	0.4	1.34	54.15	....	
Dilver	(See Platinite)						
Eureka	(See Manganin)						
Excello	85.	14.	0.5	0.5	....	....	
Fermet	18.	4.	Bal.	2.2	0.3	....	W, 0.5–1.0; C 0.35
Ferrozoid	Nickel steel						
Ia-Ia	40.	....	....	....	60.	....	
Ideal	45.	....	0.66	0.45	53.4	....	Al, 0.66
Ideal	40.	....	1.	1.	58.	....	
Invar	36.	....	64.	....	....	....	
Kromax	80.	20.	....	....	....	....	
Kromore	85.	15.	....	....	....	....	
Kruppin	28 per cent Nickel Steel						
Lucerno	67.9	....	2.4	2.2	27.5	....	
Magno	95.	....	....	5.	....	....	
Manganese Steel	....	....	Bal.	12.	....	....	C, 1.2
Manganin	4.	....	....	12.	84.	....	
Manganin	2.	....	....	12.	86.	....	
Manganin	12.	....	....	4.	84.	....	
Manganin	2.3	....	0.6	15.	82.1	....	
Manganin	5.	....	....	25.	70.	....	
Marsh's Patent	75.	25.	....	....	....	....	
Monel	67.1	....	2.1	1.7	28.4	....	
Nichroloy	75.	16.	8.	3.	....	....	
Nichroloy	40.	7.	50.	3.	....	....	
Nichroloy	23.	20.	50.	1.	....	....	
Nichrome I	60.	11.	25.	4.	....	....	
Nichrome II	75.	11.	12.	2.	....	....	
Nichrome	66.	22.	10.	2.	....	....	
Nickelin	18.	....	....	....	62.	20.	
Nickelin	32.	....	....	....	68.	....	
Nickelin	31.5	....	....	....	55.3	13.1	
Ni-Cr-Cu	80.	25.	....	....	20.	....	
Ni-Cr-Cu	85.	20.	....	....	15.	....	
Ni-Cr-Al	88.	8.	....	....	....	....	Al, 12.
Non-Magnetic High Resistance	30.	70.	....	....	....	....	
Phenix	25.	....	75.	....	....	....	
Placet	60.	15.	20.	5.	....	....	
Platinite	46–42	....	54–58	....	....	....	
Platinoid	24.77	....	0.47	0.15	54.	20.4	
Platinoid	14.	....	....	....	60.	24.	W, 1–2
Rayo	85.	15.	....	....	....	....	
Resistin	....	....	1.8	11.7	86.5	....	
Resistin	....	....	3.	12.	85.	....	
Rheotan	....	....	12.	2.	84.	4.	
Rheotan II	25.	....	5.	....	52.5	18.	
Silver Bronze	....	....	....	18.	67.5	13.	Al, 1.25; Si, 0.25
Tarnac	(See Manganin)						
Tico	30.4	....	67.3	1.12	1.1	....	
Tophet	61.	10.	26.	3.	....	....	
Vestalin	(28 per cent Nickel Steel)						

HEAT RESISTING ALLOYS.

	Ni	Cr	Fe	Cu	Mn	Other Elements
Aluminum Bronze.						
Armstrong	....	12.	Bal.	....	....	Si, 5.; C, 0.45
Calite	35.0	5.0	50.0	....	....	Al, 10.0.
Clebrium	2.0	13.1	Bal.	....	0.75	Mo, 3.6; Si, 1.5; C, 2.6
Clebrium	4.6	18.5	Bal.	2.	2.8	C, 2.0
Cobaltcrome	....	13.6	79.5	....	0.2	Co, 3.7; Mo, 0.8; Si, 0.8; C, 1.5
Duke's Metal	....	11.76	80.8	....	0.2	Si, 0.6; C, 1.45; Co, 4.; W, 0.35
Flame Resisting	9.7	14.	Bal.	....	0.77	Si, 0.2; C, 0.23
Ludlum	....	13–17	Bal.	....	....	Si, 1.; C, 0.4; Mo, 1
Monel Metal.						
Nichrome	70.3	20.	6.9	....	1.9	Si, 0.5
Nichrome	53.7	16.7	22.4	....	1.4	Si, 1.0
Nichrome	80.	13.55	4.8	....	....	Si, 1.3
Nichrome	60.2	11.1	27.2	....	1.2	C, 0.3
Nichrome	61.2	9.9	26.9	....	1.0	Si, 0.3
Nichrome	64.7	13.3	6.4	11.	0.63	Si, 3.36; C, 0.35
Nichrome	70.3	13.2	7.25	3.25	0.2	Si; 3.7; Mo, 1.33
Nichrome	67.8	11.3	6.95	7.1	....	Si, 4.65; Ti, 0.25
Nichrome	62.	13.	20.	....	5.0	
Nickel Steel	30.	1.0	Bal.	....	1.0	
Resistal	16.56	15.14	Bal.	....	....	Si, 4.66; C, 0.3
Silchrome	....	9.5	Bal.	....	....	Si, 4.; C, 0.5
Silchrome Wire	....	18.	Bal.	....	....	Si, 3.; C, 0.3; W, 3.

NON-CORROSIVE ALLOYS.

	Cr	Co	Ni	Cu	Fe	Other Elements
Bario (sheet)	4.25	....	90.	....	....	W, 1.2; Si, 0.3
Bario-Metal, Soft	20.	60.	....	....	....	W, 20.
Bario-Metal, Hard	30.	30.	....	....	....	W, 25.; Mn, 10.; Ti, 5.
Borcher's	30.	35.	35.	....	....	
Borcher's	30.	34.	34.	....	....	Ag, 2.
Borcher's	30.	35.	35.	....	....	Mo, 0.5–5
Borcher's	36.	....	....	....	60.	Mo, 4.
Borcher's	65.	....	....	....	35.	
Brix	15–20	....	60–75	5.	....	Si, 4.; W, 1–4; Al, 2.; Mn, Ti 3; B, 1
Cobaltcrome	13.6	3.7	....	....	79.5	Mo, 0.84; Si, 0.8; C, 1.5
Cobaltcrome	30–25	5–10	....	....	70–60	
Cufenium	....	....	22.	72.	6.	
Cuniloy	....	....	65.	25.	....	Mn, 35.; Pb 1.
Delhi	18.	....	....	....	....	Si, 1.5; C, 0.3–0.6; Mn, 0.3
Duke's Metal	....	....	40.	30.	30.	
Duke's Metal	11.8	4.7	....	....	89.8	W, 0.35; Si, 0.6; C, 1.45
Haynes Metal	20–30	5–25	....	....	10–75	
Haynes Metal, Hard	15.	45.	....	....	....	W, 40.
Haynes Metal, Soft	10.	62.	....	....	....	W, 28.
Ilium	21.	....	62.5	6.5	1.	Mo, 5; W, 2; Mn, 1; Al, 1.
Krupp's V1M	14.25	....	2.25	....	Bal.	C, 0.1
Krupp's V2A	23.	....	9.5	....	Bal.	C, 0.4
McFarland and Harder	43.	....	46.	11.	....	
McFarland and Harder	30.	....	59.	11.	....	
McFarland and Harder	10.	....	48.	43.	....	
McFarland and Harder	16.	....	29.	55.	....	
Nevastain	9.5	....	....	....	Bal.	Si, 3.8; C, 0.43
Non-Oxidizable, Lemarquand	....	8.	7.0	39.	....	Zn, 37.; Sn, 9.
Non-Oxidizable, Marties'	....	....	35.	17.	10.	Zn, 18.; Sn, 10.
Parr	15.	....	80.	5.	....	
Parr	18.	....	66.6	8.5	....	W, 3.3; Al, 2.0; Mn, 1.; Ti, 0.2; B, 0.2

NON-CORROSIVE ALLOYS *(Continued).*

	Cr	Co	Ni	Cu	Fe	Other Elements
Sea Water	1.2	....	24.	....	Bal.	Mn, 0.6; Si, 0.35; C, 0.5
Sea Water	....	....	16.7	....	....	Mn, 5.; Si, 0.3; C, 0.7
Sideraphite	....	....	23.	5.	63.	W, 4.; Al, 5.
Stainless (Armstrong)	12.	....	....	....	Bal.	Si, 5.; C, 0.45
Stainless (Brearley)	13.	....	....	....	Bal.	C, 0.3; Mn, 0.3
Stellite	25.	75.	....	....	....	
Stellite	25.	70.	....	....	....	W, 5
Stellite	15.	60.	....	....	....	W, 25
Stellite	15.	55.	....	....	....	W, 25; Mo, 5.
Stellite	15.	45.	....	....	....	Mo, 40.
Stellite	20–23	55.	....	....	3–5	W, 15–20; C, 1.5–4.0
Stellite	33.6	55.6	....	....	....	W, 9.2; C, 1.5
Stellite	26.4	34.5	....	....	10.	W, 12.5; Mo, 9.5; C, 1.8
Stellite	13.2	60.8	....	....	0.5	Mo, 24.1

	Si	Mn	C	P	S
Duriron	14–14.5	0.25–35	0.2–6	0.16–0.2	0.005
Duriron	14–15	2–2.5	0.75–1.25	0.05–1	0.05–0.15
Corrosimon Ironac Elianite	Similar				

REFERENCES ON COMPOSITIONS OF ALLOYS.

1. Bischoff, "Das Kupfer und Seine Legirungen" (1865).
2. Bolley, "Recherches Chimiques" (1869).
3. Brannt, "The Metallic Alloys" (1908).
4. Buchanan, "Practical Alloying" (1910).
5. Guillet, "Études Industrielle des Alliages Metalliques" (1906).
6. Guettier, "Guide Practique des Alliages" (1865).
7. Guettier, "Manufacture of Metallic Alloys" (*Trans.*, Fesquet) (1872).
8. Herve, "Alliages Metalliques."
9. Hiorns, "Mixed Metals of Metallic Alloys" (1912).
10. Krupp, "Die Legirungen" (1890), (1906).
11. Law, "Alloys and Their Individual Applications" (1914).
12. Ledebur, "Die Metallverarbeitung auf Chemisch-physikalischen Wege."
13. Roberts-Austen, "Introduction to Metallurgy."
14. Thurston, "Brasses, Bronzes and Other Alloys (III. Materials of Engineering)" (1897).
15. Kaiser, "Zusammensetzung der Gebrauchlichen Metallegierungen," *Metallurgie*, VIII, pp. 257–296 (1911).
16. Metals and Alloys, ***Metal Industry***, London (1918).
17. Wood, R. A., "The Waterbury Book of Alloys."

DISCUSSION

Mr. Job. MR. ROBERT JOB.—As a matter of information, I should like to ask regarding the explanatory note to the Tentative Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock. Note 1 reads: "The ideal composition for admiralty metal is 70 per cent of copper, 29 per cent of zinc, and 1 per cent of tin." I should like to ask whether it has been found that an excess of tin beyond 1 per cent is objectionable?

Mr. Bassett. MR. W. H. BASSETT (*Vice-Chairman, Committee B-2 on Non-Ferrous Metals and Alloys*).—It has been felt that both on account of facility in manufacturing and on account of the quality of tubes which would be obtained, that it would be best to have that figure as nearly 1 per cent as possible. A larger amount of tin makes the manufacturing difficulties greater, and we believe that the resistance to corrosion is greater with about 1 per cent of tin; therefore we tried to formulate the specification so as the secure as nearly 1 per cent as possible with the allowance of a reasonable variation. The requirement in specifications that there should be at least 1 per cent of tin, makes it necessary to always exceed 1 per cent, so that the tin runs in the neighborhood of 1.25 per cent and sometimes even more than that. Of course, some variation is necessary, but in order not to have the variation all above and the tin too high, the committee felt that it was better to allow a slight leeway under 1 per cent and thus come closer to 1 per cent, the desired standard.

Mr. Onderdonk. MR. J. R. ONDERDONK.—As I read the specifications, there is nothing to prevent putting 5 per cent of tin in if desired. My recollection of Admiralty metal is that 30 years ago it had 5 or 6 per cent of tin in it.

Mr. Bassett. MR. BASSETT.—Within my recollection, there has never been anything like 5 per cent of tin in Admiralty metal; never much more than 1 per cent. The actual variation, according to the old specifications, where 1 per cent minimum was specified, has usually been between 1 and 1.5 per cent. We believe that the situation would be best served by allowing a small leeway under the 1 per cent, the minimum being set at 0.9 per cent. We do not think an upper limit in the specifications necessary. No one would put in any more tin than he had to, as no useful purpose would be served. We have behind us the Navy Department specifications which have been in use a great many years and also a number of other specifications along the same lines. The Navy Department specifications require a minimum of 1 per cent and no maximum is given.

Mr. Clamer. MR. G. H. CLAMER.—The Corrosion Committee of the British Institute of Metals some years ago, I believe, came to the conclusion that a certain percentage of lead in the tube was desirable from the standpoint of resisting corrosion, and I should like to know whether that is really borne out in the light of the present experience, and if so, whether the present committee has given that matter consideration.

Mr. Bassett. MR. BASSETT.—An alloy with lead in it would not be considered Admiralty metal. It would require a separate specification as another alloy, if its use were to be considered. Tubes made in England with lead instead of tin in several instances were imported into this country with the idea that they would be better than Admiralty, but were found to be very much inferior to it in their resistance to corrosion. The use of such tubes has made no headway, although they were proposed six or eight years ago. They have not proved to be satisfactory under our conditions.

REPORT OF COMMITTEE C-1

ON

CEMENT.

Committee C-1 has the pleasure of reporting to the Society that its efforts in behalf of one generally accepted "Specifications and Tests for Portland Cement" have been rewarded by having had the Standard Specifications and Tests for Portland Cement (C 9 – 21), as adopted by the Society, accepted as "American Standard Specification No. 1" by the American Engineering Standards Committee.

It is not the desire or intention of Committee C-1 to rest on this honor but it has planned to continue its research work along further lines, to consider fully suggestions regarding methods of tests, to study the effects that admixtures used with cement may have upon cement when in concrete, and to also investigate further the qualities and what constitute the qualities of portland cement.

In order to plan a scope of research along this latter line of study a special sub-committee is developing an outline for such intensive investigation.

It was hoped that Committee C-1 could make at this meeting of the Society positive recommendations regarding the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 – 16 T). The committee feels, however, that further studies should be made in regard to the strength requirements before making positive recommendations and it has therefore outlined a series of tests that will involve the testing of portland cements made from all kinds of materials and made in all parts of this country and Canada. The committee feels that the present standard for portland cement is the means of securing a satisfactory cement and to continue the same standard requirements by means of compression rather than tension tests would mean that equal demands as to quality should be made in the requirements. The committee therefore asks that the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars be continued as tentative by the Society until these further studies have been completed. The committee also again requests that comparative data on tension and compression tests be sent to the committee for study in connection with the proposed requirement.

The committee also realizes that the methods of tests outlined in the standard specifications, may not be thoroughly understood, or its details fully appreciated, by new and inexperienced laboratory operators, so it proposes to prepare and to publish a hand-book which will be of service toward producing more uniform and concordant results between operators and laboratories.

This report has been submitted to letter ballot of the committee, which consists of 61 members, of whom 54 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted in behalf of the committee,

RUSSELL S. GREENMAN,
Chairman.

P. H. BATES,
Secretary.

REPORT OF COMMITTEE C-2
ON
REINFORCED CONCRETE.

Committee C-2 on Reinforced Concrete has held meetings on October 28, December 21, 1921, March 9, and June 3, 1922, at which it devoted its efforts to the preparation of the Proposed Tentative Rules for the Inspection of Concrete and Reinforced Concrete Work which are herewith submitted[1] with the recommendation that they be accepted for publication as tentative by the Society, and to a discussion of the Tentative Specifications for Concrete and Reinforced Concrete appearing in the Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, and has transmitted to the Executive Committee of the Society its suggested additions to and corrections of the specifications.

Ten members of Committee C-2 are members of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete and they have actively participated in the Joint Committee's work and its meetings held on October 4 and 5, December 9, 1921, February 17, and June 1 and 2, 1922.

These members attended the six sessions of the American Society of Civil Engineers held in New York City on December 7 and 8, 1921, and the two sessions of the American Concrete Institute, held in Cleveland, Ohio, on February 16, 1922, at which the Tentative Specifications for Concrete and Reinforced Concrete were discussed. In addition these members have also participated in the work and attended meetings of the various sub-committees of the Joint Committee.

This report has been submitted to letter ballot of the committee, which consists of 22 members, of whom 17 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

RICHARD L. HUMPHREY,
Chairman.

S. C. HOLLISTER,
Secretary.

EDITORIAL NOTE.

The proposed Tentative Rules for Inspection of Concrete and Reinforced Concrete Work referred to in this report were accepted for publication as tentative and appear on page 734.

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[1] See p. 734.—ED.

REPORT OF COMMITTEE C-3

ON

BRICK.

The activity of Committee C-3 during the past year is probably best illustrated by the fact that since the last meeting of the Society we have doubled our membership, and organized six new sub-committees.

The long standing conflict between Committees C-3 on Brick and Committee D-4 on Road Materials as to jurisdiction over paving brick has finally been adjusted by the election of a member of Committee D-4 to membership on Committee C-3.

A Conference on Elimination of Unnecessary Sizes and Types of Paving Brick has been organized by the Department of Commerce. On recommendation of Committee C-3, Mr. Blair has been appointed by the Society to represent it on this Conference. The Conference has recommended the reduction of the present 66 sizes and types of paving brick to the following seven:

	Width, In.	Depth, In.	Length, In.
Plain wire-cut brick (vertical fiber, lugless)	3	4	8½
" " " " " "	3½	4	8½
Repressed lug brick	3½	4	8½
Wire-cut lug brick (Dunn)	3½	3	8½
" " " "	3½	3½	8½
" " " "	3½	4	8½
Hillside lug brick (repressed)	3½	4	8½

The sizes stated above are to be regarded as nominal and subject to the usual variation of ⅛ in. in width and depth, and ½ in. in length. It is the recommendation of this committee that the action of the Conference be formally approved by the Society, and the sizes enumerated above be included in our Standard Specifications for Paving Brick (C 7 – 15).[1] The letter ballot of the committee on this recommendation resulted as follows: Affirmative, 21; negative, 0; not voting, 2.

The Tentative Specifications for Clay Sewer Brick (C 32 – 21 T) have been discussed at some length, and several changes seem to be desirable. However, the discussion is still in active progress, and it therefore seems inadvisable to make any changes at this time. It is therefore recommended that these specifications be continued, without change, as tentative for another year.

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[1] 1921 Book of A.S.T.M. Standards.

The committee is now organized to prepare specifications for sewer brick of material other than clay, should the need for such specifications arise.

Some criticisms have been received of our Standard Specifications for Building Brick (C 21 - 20). While these are being given due consideration, it is not desirable to recommend any changes at this time.

In accordance with the recommendation of the Executive Committee, this committee has enlarged its personnel and taken jurisdiction over concrete brick. Tentative Specifications for Concrete Building Brick were prepared by a sub-committee. On reference to letter ballot of the committee, the vote was as follows: Affirmative, 10; negative, 12. This action of the committee to fail to recommend the tentative specifications for acceptance was apparently prompted by a desire for more information about concrete brick and for the time to study the proposed specifications. The specifications were therefore referred back to the sub-committee, together with the data on which the specifications were based.

This report has been submitted to letter ballot of the committee, which consists of 23 members, of whom 20 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

T. R. LAWSON,
Chairman.

W. E. EMLEY,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Standard Specifications for Paving Brick referred to in this report were accepted for publication as tentative and appear on page 986.

REPORT OF COMMITTEE C-4

ON

CLAY AND CEMENT SEWER PIPE.

Since the last annual meeting, Committee C-4 has held two meetings, both well attended.

The committee gave consideration to revising the definitions of terms Clay, Fire-Clay, and Shale appearing in the Standard Specifications for Clay Sewer Pipe (C 13 – 20) and is cooperating with Committee E-8 on Nomenclature and Definitions in the preparation of definitions of these terms.

The matters now principally engaging the attention of the sub-committees are briefly:

Sub-Committee I on Absorption and Hydrostatic Pressure Test Requirements.—This sub-committee is giving further consideration to test methods.

Sub-Committee II on Chemical Requirements.—At a meeting of the committee on January 17, 1922, this sub-committee was reorganized and was requested to report, at the time of the annual meeting, recommendations covering the advisability of continuing the work of this sub-committee and, in the event of a favorable report, the nature of the work which should be undertaken.

Sub-Committee III on Dimensions and Their Permissible Variations.—This sub-committee will consider and report on suggestions which have been made for another class of sewer pipe in certain sizes.

Sub-Committee IV on Methods of Testing will cooperate with Committee E-1.

Sub-Committee V on Nomenclature and Definitions will cooperate with Committee E-8.

It is recommended that the Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling (C 15 – 17 T) be continued as tentative for another year.

The chairman of the committee, being obliged to go to Europe for an indefinite period, presented, in January, 1922, his resignation. The committee voted, however, to take no action prior to the time of the annual meeting.

This report has been submitted to letter ballot of the committee, which consists of 27 members, of whom 24 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

RUDOLPH HERING,
Chairman.

GEORGE T. HAMMOND,
Secretary.

A. J. PROVOST, JR.,
Vice-Chairman.

ADDENDUM TO REPORT OF COMMITTEE C-4.

At a meeting of Committee C-4 held on Thursday, June 29, 1922, prior to the presentation of its annual report to the Society, revisions of the Standard Specifications for Clay Sewer Pipe (C 13 – 20)[1] and of the Standard Specifications for Cement-Concrete Sewer Pipe (C 14 – 20)[1] were recommended by unanimous action to be presented to the Society in connection with the printed report of the committee. The revisions recommended to be made are identical in the two specifications and are as follows:

Section 6.—Omit the last sentence. Add to the preceding sentence the words "except that in no case shall the number of specimens furnished be less than five."

Table II.—Physical Test Requirements of Sewer Pipe.

Internal Diameter, in.	Average Crushing Strength, lb. per lin. foot.		Maximum Absorption, per cent.
	Knife Edge[1] and Three-Point[2] Bearings.	Sand Bearing.[3]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8
39	3300	4710	8
42	3520	5030	8

[1] See Section 11. [2] See Section 12. [3] See Section 13.

Section 7.—Insert after the word "test" in the seventh line, the words "without charge." Omit the words "without charge" in the eighth line and substitute the words "to be selected as specified in Section 6." Add a new paragraph to read as follows:

> "In addition to the foregoing requirements, failure of individual specimens to develop 75 per cent of the average crushing strength requirements shall be cause for rejection of the shipment, but the seller may cull the pipe and submit the balance of the shipment for re-test, and, if the shipment then passes all of the requirements of these specifications, it shall be accepted."

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[1] 1921 Book of A.S.T.M. Standards.

Section 11.—Omit the portion of the last sentence reading as follows:

"and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00"

Table II.—Amend Table II to read as indicated in the accompanying table.

Respectfully submitted,

RUDOLPH HERING,
Chairman.

GEORGE T. HAMMOND,
Secretary.

A. J. PROVOST, JR.
Vice-Chairman.

EDITORIAL NOTE.

The proposed revisions of the Standard Specifications for Clay Sewer Pipe and of the Standard Specifications for Cement-Concrete Sewer Pipe as given in the Addendum to this report were referred to letter ballot of the committee subsequent to the annual meeting. This ballot resulted as follows: Affirmative, 18; negative, 0; not voting, 9. The revisions were accordingly accepted for publication as tentative and appear on pages 986 and 987, respectively.

REPORT OF COMMITTEE C-5
ON
FIREPROOFING.

Committee C-5 on Fireproofing presents for the first time in several years, a report with recommendations for revisions in the present Standard Specifications for Fire Tests of Materials and Construction (C 19 – 18).[1] The work of this committee was practically suspended for a few years, pending an investigation on the resistance to fire of columns of different types and various methods of protection, made at the Underwriters' Laboratories in Chicago, under the joint auspices of the Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, and the U. S. Bureau of Standards, Department of Commerce. The tests were made during the years 1917 to 1919, and the results of these tests are embodied in a report issued jointly by the three sponsors some time early in 1920. Sufficient time had not elapsed after the publication of the report for consideration of the results and the preparation of recommendations by this committee for presentation last year.

The committee, in the consideration of the changes that are recommended below and the formulation of the additional matter, invited to confer with it those representatives of other interests who had taken part and assisted in the preparation of the original specifications that were adopted in 1918 under the serial designation C 19 – 18.

The committee is especially indebted to S. H. Ingberg of the Bureau of Standards, Washington, D. C., for the great interest he has shown in this work, and the assistance he has given the committee in the preparation of the additional specifications. Mr. Ingberg was closely identified with the fire tests of building columns above referred to, as the representative of the Bureau of Standards, during the entire period of the investigation. His great familiarity with all the details of that work and his thorough study of the results have qualified him more than any other man, to outline the specifications for such tests.

Five new sections covering the method for testing columns have been prepared by the committee to be added under the general head "VIII. Column Tests." The experience gained during the investigation on columns indicated that certain changes in the existing specifications were desirable. Careful consideration has been given to recommendations made by Mr. Ingberg in this respect, and changes are herewith submitted.

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[1] 1921 Book of A.S.T.M. Standards.

The proposed new matter relating to column tests seems sufficiently self-explanatory to require no further comment. The proposed sections are as follows:

19. *Size of Sample.*—For column tests, the length of the column exposed to fire shall approximate the clear length of the member in the structure, and for building columns shall be not less than 9 ft. The outside lateral dimension shall be the minimum for which classification is desired. The details of construction, and exposed connections and protection, if any, shall be applied according to the methods of acceptable field practice.

20. *Loading.*—During the fire test and the fire and water test, a constant working load shall be applied to the column, calculated according to the governing design regulations. Provisions shall be made for transmitting the load to the exposed portion without unduly increasing the effective column length.

21. *Measurements.*—Measurements shall be made of the expansion or depression at the head of the column and determination of the period of expansion. Such other measurements shall be made of deformation and of temperature of the column as will give the most useful information for the given column type.

22. *Position of Nozzle.*—The distance of the nozzle from the column during the application of water shall be 20 ft., the water being applied in succession, as uniformly as possible, over the full height on three of its sides.

23. *Conditions of Acceptance.*—The test shall not be regarded as successful unless the following conditions are met:

(*a*) The column shall have sustained the full working load during the fire test for a period equal to —[1] times that for which classification is desired.

(*b*) The column shall have sustained the full working load during the fire stream test as prescribed in Sections 7 and 8, and after its completion and when cold shall sustain a total load equal to the dead load component plus twice the live load component of its design working load.

(*c*) After the fire stream test the column when dry shall withstand, under working load, a fire test of duration equal to —[1] of the period for which classification is desired, but not exceeding one hour.

The proposed changes in the existing specifications are as follows:

Section 2. (*a*).—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The temperature fixed by the curve shall be deemed to be the average [true] temperature [of the furnace gases as] obtained from the readings of several thermo-couples (not less than three) symmetrically disposed and distributed [in such a manner as] to show [temperatures of the gases] *the temperature* near all parts of the sample, *said thermo-couples being enclosed in sealed porcelain tubes of* $^3/_4$*-in. outside diameter and* $^1/_8$*-in. wall thickness, the immersion of the couple in the furnace chamber to be not less than 12 in. Other types of protecting tubes or pyrometers may be used that under test conditions give the same indica-*

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[1] The quantity to be inserted in this blank space will be supplied by the committee when the information is available.

tions as the above standard within the limit of accuracy that applies for furnace temperature measurements.

"For greater difference of design and size, the time temperature curve followed shall be modified to give an exposure equal to that obtained by using the standard pyrometer and curve above described."

Experience in the tests on columns has shown that according to the type of thermo-couple used, more or less difficulty is experienced in securing the true temperature at any one time. In certain tests, the casing around the thermo-couple must be of greater strength than in others, and the time required to get the outer temperature reading is dependent on the conductivity of the materials that form the casing of the thermo-couple. In other words, until the casing itself has been thoroughly heated through so as to have the temperature of the interior of the furnace, the thermo-couple records a lower temperature. There are also radiation effects which are dependent mainly upon the size of mounting.

Section 6.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "The fire test on the sample with its applied load, if any, shall be continued until failure occurs, or until it has withstood the test conditions for a period equal to [1½ times that for which classification is desired] *that herein specified in the Conditions of Acceptance for the given type of construction.*"

It was thought better to give the time factor for each type of construction tested under the specified conditions of acceptance in each case.

Section 7.—Change to read as follows by the addition of the italicized word and the omission of the word in brackets:

> "A second test with duplicate sample shall be made to determine the effect of a hose stream on a sample under fire test, the water being applied at the end of a period equal to [three-fourths] *one-half* of that for which classification is desired, but not later than one hour after the beginning of the test; except that for classification periods of one-half hour or less the fire stream test may be omitted.

It is thought that the shorter fire exposure before water application is more nearly representative of the time water will be applied, if at all, in actual fires.

Table I.—Change Table I, referred to in Section 8, to read as indicated in the accompanying Table I by the addition of the italicized word and figures and the omission of the word and figures in brackets.

It was considered, in the light of more recent experience, that the time of application of the water, especially as given for floors and roofs, was unnecessarily long.

Section 9.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets, changing the side heading from "Loading" to "Loading and Additional Tests":

> "For any material or construction intended to carry load other than its own weight, the full [rated safe] working load shall be applied during the entire fire test, also during the fire stream test. After completion of the fire stream test, the sample shall be subjected to [excess loading as prescribed under specifications for the different structural parts] *additional tests as herein specified in the Conditions of Acceptance for the given type of construction.*"

The committee feels that the time of testing specimens should be a matter of general application. It, therefore, proposes a new Section 10, under the sub-division "Conduct of Fire Tests," entitled "Time of Testing," to read as follows:

TABLE I.

Parts of Structure	Type of Protection.	Size of Hose Nozzle, in.	Water Pressure at Nozzle, lb.	Time of Application, min.
Floors and Roofs	4 hour	1 1/8	50	[10] *7*
	2 "	1 1/8	50	[5] *4*
	1 "	1 1/8	50	[2.5] *2*
	1/2 "	1 1/8	30	1
	1/4 "	1 1/8	[15] *30*	1
Walls[, Columns] and Partitions	4 "	1 1/8	50	5
	2 "	1 1/8	30	3
	1 "	1 1/8	30	[2.5] *2*
	1/2 "	1 1/8	30	1
	1/4 "	1 1/8	[15] *30*	1
Columns	*4* "	*1 1/8*	*50*	*3*
	2 "	*1 1/8*	*30*	*2*
	1 "	*1 1/8*	*30*	*1 1/2*
	1/2 "	*1 1/8*	*30*	*1*
	1/4 "	*1 1/8*	*30*	*1/2*

> "The material or construction shall not be tested until a large proportion of its final strength has been attained and the excess of free water has been given off. Where this cannot be attained within 40 days, artificial drying with air temperature not exceeding 100° F. shall be used."

Section 10.—Renumber the present Section 10 to Section 12.

Section 11.—Omit this section reading as follows:

> "The floor or roof may be tested as soon after construction as desired, but within 40 days. Artificial drying will be allowed if desired."

Section 12.—Transfer this section, placing it under the sub-division "Conduct of Fire Tests," renumbering it Section 11.

Section 14.—Change the side heading to read "*Conditions of Acceptance.*

Section 14. (*a*).—Change to read as follows by the omission of the words in brackets:

> "The floor or roof shall have sustained safely the full [rated safe] working load during the fire test without passage of flame for a period equal to 1¼ times that for which classification is desired."

An examination of the results of tests, more especially in the case of columns, shows that the time rating based on a period equal to one and one-fourth times that for which the classification is desired, will in some cases give a higher rating than the shortest duration developed in some of the tests entering into the determination of the average. For this reason, it was felt that this factor of one and one-fourth should be changed in all cases to one and one-half.

Section 18.—Change the side heading to read "Conditions of Acceptance."

The committee recommends the adoption of the additional sections reported above, and of the revisions of the existing sections as outlined. The committee further recommends that these additions and changes be printed as tentative, so that the committee may have the benefit of criticism and discussion that may develop in the course of the next year.

As the existing standard specifications have been approved as a Tentative American Standard by the American Engineering Standards Committee, any changes in the Specifications must have the approval of that organization. Therefore, in order to proceed with the work in conformity with the Rules of Procedure of the A.E.S.C., the committee recommends that the Executive Committee of the Society present these suggested revisions to the A.E.S.C. for consideration, with the request that the A.S.T.M. be appointed as the sponsor body for the purpose of coordinating all interests in this subject and further developing the proposed revisions.

This report has been submitted to letter ballot of the committee, which consists of 14 members, of whom 10 have voted affirmatively, none negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

IRA H. WOOLSON,
Chairman.

RUDOLPH P. MILLER,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Standard Specifications for Fire Tests of Materials and Construction referred to in this report were accepted for publication as tentative and appear on page 988.

REPORT OF COMMITTEE C-6

ON

DRAIN TILE.

Committee C-6 has held two meetings during the year: one at Asbury Park, N. J., at the time of the annual meeting of the Society, and the other in Chicago, April 8, 1922.

Professor A. N. Talbot, a member of the committee since its first organization, has resigned during the year owing to great pressure of similar duties, and the committee has felt that his splendid service has earned him the right to have his wishes in the matter respected. At the meeting in Chicago the committee requested the chairman to write Professor Talbot expressing deep appreciation of his service during the past years.

Mr. J. T. Stewart, who has served as secretary of the committee since its organization, has recently severed his connection with the Portland Cement Association, which he represented on the committee. The committee expresses deep regret at losing his services as secretary.

The committee recommends no changes in the Standard Specifications for Drain Tile (C 4 – 21).

During the year the Standard Specifications for Drain Tile have been under consideration by the American Engineering Standards Committee and were adopted on March 23, 1922, as "Tentative American Standard."

In its 1921 report, Committee C-6 announced a general program of research investigation on the development of chemical tests and chemical test requirements for drain tile to determine their resistance to the action of alkalis and acids in the soil. The committee would now report progress on the various experimental researches which are under way with general coordination by Committee C-6, as follows:

1. The Iowa Engineering Experiment Station has conducted active work during the year in the effort to determine practicable laboratory chemical tests of drain tile. This work was carried on by Mr. W. J. Schlick, Drainage Engineer of the Experiment Station Staff, who reports concerning his work as follows:

In order to correlate the results of laboratory investigations with those of field trials, pieces from reserve tile from the stock prepared by the Bureau of Standards for their field investigations (started in 1912) were used. The principal studies have been of the chemical action of solutions of various salts common to natural alkalis. One piece from each of five tile from 15 of the 21 series prepared by the Bureau of Standards has been immersed in the following solutions: 15, 10, 5 and 2-per-cent solutions of sodium sulfate; 15 and 10-per-cent solutions of magnesium sulfate; a 10-per-cent solution of sodium and of magnesium chlorides; and a 15-per-cent solution of sodium carbonate. The comparative effects of the standard boiling absorption test and a 72-hour-immersion absorption test on the action in a 10-per-cent solution of sodium sulfate were studied.

The combined physical and chemical effect of alternate wetting and drying in alkali soils was studied with another set of pieces by alternately immersing them in a 15-per-cent solution of sodium sulfate and drying in various ways.

The results so far obtained may be summarized as follows:

1. The pieces in the sodium and magnesium sulfate solutions were attacked in much the same ratio as were the tile in the field. (See *Technologic Papers Nos. 44 and 95*, U. S. Bureau of Standards.) The actions by the magnesium sulfate were more rapid than those of any other solutions, and the higher concentrations of both sodium and magnesium sulfate solutions were the more effective.

2. The specimens in the combined physical and chemical test, except those from tile of series 15 which were made with a sand-cement, were attacked in much the same order as those in the chemical tests using sulfate solutions. The action in this test was more rapid than that where there was only chemical action, and the appearance of the attacked specimens clearly indicated physical disrupting forces.

3. No action was visible after immersion for nine months in the chloride solutions or for twelve weeks in the solution of sodium carbonate.

4. Some of the treatments are worthy of consideration for adoption as test methods for application to the product of a factory, but require too much time and expense for use in accepting or rejecting individual samples of tile.

5. These studies have shown, as a general relation between the rapidity of attack in any of the solutions and the readily determined physical properties of the tile, that the stronger, more dense tile are the more durable. However, the variations in the physical properties of individual specimens are such as to present many apparent contradictions of the general law.

Mr. Schlick will continue his work during the coming year and will extend it to investigation into possible laboratory tests of the resistance of tile to organic acids.

2. The most extensive research into the resistance of concrete to alkali attack is being carried on by the Structural Materials Research Laboratory of the Lewis Institute. Professor Abrams, in charge of the laboratory, reports thereon as follows:

Our investigations were designed to bring out the effect of the following factors on the resistance of concrete to alkali action:

Effect of consistency of concrete;
Effect of size of aggregate;
Effect of grading of aggregate;
Effect of type of aggregate;

Effect of constitution of cement;
Effect of powdered admixtures;
Effect of integral water and alkali-proofing compounds;
Effect of surface coatings;
Effect of age and curing condition of concrete;
Comparison of results of field and laboratory tests.

This is the most comprehensive experimental study of concrete exposed to alkali that has been undertaken. About 1750 10 by 24-in. concrete cylinders have been made for field exposure in alkali soils in Colorado, South Dakota and Western Canada, and about 6000 4 by 8-in. cylinders for exposure in the laboratory to various alkali solutions. Parallel specimens are also being made for compression tests of concrete. In this work we are cooperating with the U. S. Bureau of Standards, Reclamation Service, Bureau of Public Roads and the Engineering Institute of Canada.

Field specimens were placed upright in soils which were continuously saturated with alkali-bearing water—the alkali consisting largely of magnesium and calcium sulfates.

The field specimens were installed in 1921 and have not since been examined; consequently we are not in position at this time to report any results from these investigations.

3. Mr. S. H. McCrory, Chief of the Division of Agricultural Engineering, U. S. Department of Agriculture, reports as follows concerning research work under his direction on the effect of alkali and acid soil conditions on the durability of drain tile:

The U. S. Department of Agriculture in cooperation with the University of Minnesota and the Department of Drainage and Water, State of Minnesota, has been studying the effect of the so-called alkalis upon tile and has been endeavoring to work out methods of improving the quality of the tile. The Department of Agriculture has in progress investigation of the deterioration of tile in the Southeastern states."

4. The Concrete Pipe Association is conducting a series of field tests in which concrete pipe of various types are being exposed to alkali conditions in the field. Committee C-6 has had no definite report on the progress of this investigation.

5. Professor G. R. B. Elliott of the University of Minnesota (formerly of the University of Wisconsin), has conducted an investigation since 1919 into the effect of peat soils upon the durability of drain tile, and has kindly furnished Committee C-6 with a very full report of his work, including a considerable number of photographs showing disintegration of tile.

In brief, Professor Elliott finds considerable disintegration of concrete drain tile laid in peat soils in four geological formations in Wisconsin and three in Minnesota, under several different soil conditions, including both high and low-lime soils. He reports that this disintegration became serious in from one to eleven or more years.

He gives one photograph of a concrete tile 36 years old from a sewer at Milwaukee. Professor Elliott states:

> Though under certain conditions the life of a concrete tile in peat soil may be very short, under certain other conditions it may last a long time. In general it may be said that the average life of a concrete tile as they have been made is about six years.

Professor Elliott's theory of the cause of the disintegration is that the rotting of the peat soils in the summer time produces organic acids which attack the tile (whose reaction is alkaline). He gives the results of experiments showing the development of acidity in the laboratory when samples of peat were placed in glazed earthen jars in distilled water and allowed to stand ten days in a warm room.

On the other hand, Dr. J. C. Witt of the Structural Materials Research Laboratory of Lewis Institute reports that samples of water taken from the same peat bogs in which Professor Elliott found disintegration of the tile showed very weak acidity, if any, and he expressed considerable doubt that the traces of acid which were found in the samples sent to the laboratory would be of sufficient concentration to affect good concrete in any way. The samples of soil taken from these same peat bogs at the same points from which the ground water samples were taken showed alkaline reaction in every case. Dr. Witt also applied the tests which have been used by Dr. Emil Troug, a soil chemist of the University of Wisconsin, and found that these tests gave a negative reaction.

It has been claimed that the tile which Professor Elliott found disintegrated were very poor in quality and Professor Elliott himself says on this point, "It is true they were not good tile, yet they were no worse than many hundreds of miles of tile that have been used."

Committee C-6 plans to continue the research program announced in 1921 on which progress is reported above and hopes to develop standard chemical tests for concrete drain tile and standard chemical test requirements within the next two or three years.

Mr. E. H. Berger, U. S. Bureau of Standards, Department of Commerce, is representing Committee C-6 on Committee E-8 which has under consideration the adoption of uniform definitions of clay, shale and fire clay.

At the meeting of Committee C-6 held in Chicago, April 8, 1922, a sub-committee was appointed on standard sizes of drain tile, which held a meeting and reported the following recommendations:

> "1. That this sub-committee be made permanent and that the chairman of Committee C-6 appoint as chairman of the sub-committee a non-producer.

"2. That the committee be composed of five members, three of whom shall be non-producers.

"3. That this committee communicate and cooperate with the American Society of Agricultural Engineers and any other interested organizations with the view of formulating a joint report and recommendation."

The committee further reported that the adoption of standard sizes "would cause and bring about a large saving in equipment, stock on hand, interest on investment on stock and plant and the cost of changing machinery in the manufacturing of the various sizes."

The above report was adopted unanimously. The chair appointed as members of the Sub-Committee on Standard Sizes of Drain Tile the following:

Professor G. W. Pickels, University of Illinois, Urbana, Ill., *Chairman*.

U.S. Bureau of Public Roads and Agricultural Engineering, Department of Agriculture, Washington, D. C., represented by Mr. S. H. McCrory.

Professor George R. Chatburn, University of Nebraska, Lincoln, Neb.

Clay Products Association, represented by Mr. George C. D. Lenth, Chicago, Ill.

Concrete Pipe Association, 111 W. Washington St., Chicago, Ill.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 13 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

ANSON MARSTON,
Chairman.

REPORT OF COMMITTEE C-7

ON

LIME.

During the year the committee held two meetings. Some sub-committees held special meetings. At the committee meeting held in Philadelphia in December there was a special open session to which the local organizations of architects, of plasterers and of brick and stone masons were invited. Specialists of the committee gave four short lectures on raw materials and the processes in the manufacture of lime and on its applications in construction and decorative work. The visitors took an active part in the discussion which followed the formal talks.

The number of specifications is growing so large that the committee recommends a policy of condensation by adopting:

1. Definitions which shall be given once only in the current publications of the Society;

2. Clauses for sampling, inspection, rejection, packing and marking in one document to which reference is made in each specification in place of quoting these clauses *in extenso* in each.

3. Specifications for the various kinds of lime required for the various technical industries, each to be published as a separate document.

This policy will lead to considerable reduction in the cost of publication and be of greater convenience to the user because of the shorter document in which he may be especially interested and the brevity of the essential parts of his specification.

The various activities of the committee are mentioned in condensed statements from the reports of the sub-committees:

Sub-Committee I, consisting of the chairmen of all sub-committees, was reorganized during the year to act as an executive committee to prepare the annual report and to correlate the work of the various sub-committees. It held one special meeting.

Sub-Committee II on Structural Lime.—This sub-committee has revised the Tentative Specifications for Quicklime for Structural Purposes (C 5 – 21 T), and the Tentative Specifications for Hydrated Lime for Structural Purposes (C 6 – 21 T) to conform to the policy of change of form in specifications and to slightly change the method of measuring plasticity as dictated by a wider experience with the apparatus. The revised specifications are appended[1] to this report and are recommended for publication as tentative to replace the present Tentative Specifications for Quicklime and for Hydrated Lime.

The sub-committee calls attention to the insertion of a clause in the Tentative Methods of Sampling, Inspection Packing and Marking of Quicklime and Lime Products which permits the manufacturers of quicklime and lime products to print upon the package a statement that the contents of the package are guaranteed to meet the requirements of the A.S.T.M. specifications for the uses stated on the package.

Work is being conducted actively on a method for determining the apparent density of quicklime in the hope that this property may be used as a measure of the degree of overburning.

Ninety-eight panels of lime plaster have been erected at the Bureau of Standards to determine the effect on the quality of the plaster, of certain impurities which may be found in hydrated lime or sand. This work is being carried on by cooperative arrangements between the National Lime Association, the Contracting Plasterers' International Association and the International Plasterers' Union.

The sub-committee does not recommend a specification for plastering sand, but believes it more practical to inform contractors how best to use sands available. To this end, work is being carried on to find a method for measuring sand-carrying capacity of lime.

The sub-committee has felt its responsibility for the preparation of a rebuttal to the discussion by D. A. Abrams of our 1921 report. This rebuttal will be found in Appendix I.

On the recommendation of this sub-committee, Committee C-7 has adopted the following resolution:

> "That certain paragraphs contained in the report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete may be construed as being inimical to the use of hydrated lime, which discrimination in the judgment of this committee is not justified by the demonstrated facts."

Sub-Committee III on Lime for Chemical Industries.—This sub-committee has been reorganized since the last annual meeting of the Society. It has enlarged on the work of the previous sub-committee and prepared the following tentative specifications:[2]

1. For Quicklime and Hydrated Lime for Use in the Cooking of Rags for the Manufacture of Paper.

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[1] See pp. 688–696.—ED.

[2] See pp. 697–706.—ED.

2. For Quicklime and Hydrated Lime for Use in the Manufacture of Sulfite Pulp.

3. For Hydrated Lime for the Manufacture of Varnish.

4. For Quicklime and Hydrated Lime for Use in the Textile Industry.

5. For Quicklime and Hydrated Lime for the Manufacture of Silica Brick.

The sub-committee, through its chairman M. E. Holmes, is in close contact with the technical trade organizations of the various industries and is working actively on the preparation of specifications for use of lime in such industries. It is expected to have a number of these ready for presentation at the next annual meeting.

Sub-Committee V on Methods of Analysis has received no adverse criticism of the revised Tentative Methods of Chemical Analysis of Limestone, Lime and Hydrated Lime (C 25 - 21 T) submitted last year except that the title should be revised to read "Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime." This change in title is recommended and a new section on "Determination of Available Lime" has been prepared, as appended hereto,[1] for inclusion as an integral part of the tentative methods. The sub-committee has also prepared proposed Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products, as appended hereto, for publication as tentative.[2]

The sub-committee is in conference with a sub-committee from the Association of Official Agricultural Chemists to establish standard methods of analysis acceptable to both societies.

Sub-Committee VI on Plasticity reports that a number of Emley plasticimeters made to meet the requirements of the Tentative Specifications for Hydrated Lime are in use in different laboratories. This improved apparatus is now available to the industry.

The latest information indicates that the sand-carrying capacity of a lime is a function of the plasticity of the mortar. The measurement of sand-carrying capacity on this principle is therefore being conducted as a cooperative research between this sub-committee and the Sub-Committee on Structural Lime.

The sub-committee realizes the growing recognition of the demonstrated beneficial effects of the workability, water-tightness, strength, etc., to be derived from the addition of small amounts of hydrated lime to portland-cement concrete. The sub-committee is therefore engaged in an effort to find a method for measuring the workability of concrete, and to correlate changes in workability with other properties of concrete. Experience indicates that workability is similar in many respects to plasticity, probably a complex function of plasticity and consistency.

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[1] See p. 724.—ED.

[2] See p. 728.—ED.

Sub-Committee VII on Highway Lime has been working chiefly to determine the effects of hydrated lime in portland-cement concrete mixtures. A number of additional investigations have been carried on, results from some of which are given in Appendices II, III and IV.

Investigations have been outlined to experiment with hydrated lime in the construction of sand-clay roads and in topsoil road construction, to learn its value, if any, to nullify the effect of organic impurities.

Sub-Committee VIII on Nomenclature has submitted lists of terms relating to lime or its uses to the chairmen of the various sub-committees. Appended hereto[1] are proposed Tentative Definitions of Terms Relating to Lime which the committee recommends be accepted for publication as tentative.

Committee C-7 recommends the adoption by the Society of the several recommendations contained in this report and tabulated below with the results of the letter ballot vote of the committee.

Items.	Affirmative.	Negative.	Not Voting.
I. REVISIONS OF TENTATIVE STANDARDS.			
1. Specifications for Quicklime (C 5 - 21 T)	22	0	14
2. Specifications for Hydrated Lime (C 6 - 21 T)	22	1	13
3. Methods of Chemical Analysis of Limestone, Lime and Hydrated Lime (C 25 - 21 T)	18	0	18
II. SUBMISSION OF NEW TENTATIVE STANDARDS.			
4. For Quicklime and Hydrated Lime for Use in the Cooking of Rags for the Manufacture of Paper	20	0	16
5. For Quicklime and Hydrated Lime for Use in the Manufacture of Sulfite Pulp	18	1	17
6. For Hydrated Lime for the Manufacture of Varnish	18	0	18
7. For Lime for Use in the Textile Industry	21	0	15
8. For Lime for the Manufacture of Silica Brick	20	0	16
9. Definitions of Terms Relating to Lime	23	2	11
10. Methods of Sampling, Inspection, Packing and Marking of Lime and Lime Products	25	1	10

This report has been submitted to letter ballot vote of the committee, which consists of 36 members, of whom 25 have voted affirmatively, 1 negatively, and 10 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. C. BERRY,
Chairman.

R. P. BROWN,
Acting Secretary.

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[1] See p. 731.—ED.

EDITORIAL NOTE.

The proposed revisions of the Tentative Specifications for Quicklime for Structural Purposes, of the Tentative Specifications for Hydrated Lime for Structural Purposes, and of the Tentative Methods of Chemical Analysis of Limestone, Lime and Hydrated Lime referred to in this report were accepted. The tentative standards as thus revised appear on pages 688, 691 and 715, respectively.

The five proposed Tentative Specifications listed as items 4 to 8 in the table on page 267 were accepted for publication as tentative and appear on pages 697 to 706. The proposed Tentative Definitions of Terms Relating to Lime referred to in this report were accepted for publication as tentative and appear on page 731. The proposed Tentative Methods of Sampling, Inspection, Packing and Marking of Lime and Lime Products were accepted for publication as tentative and appear on page 728.

For a discussion of this report, see page 292.

APPENDIX I.

ANALYSIS OF TESTS ON EFFECT OF HYDRATED LIME IN CONCRETE MADE AT LEWIS INSTITUTE.

BY T. B. SHERTZER.[1]

Two years ago a paper was presented by D. A. Abrams before the American Society for Testing Materials entitled "Effect of Hydrated Lime and Other Powdered Admixtures in Concrete."[2] Last year a supplementary paper was presented on the same subject in which a report was made of some additional tests and data obtained from longer time tests of the original series.[3]

This is the first opportunity which has presented itself, since the presentation of these papers, for a discussion of the data and conclusions therein contained.

One who has devoted as much time to the study and analysis of these data, as the speaker has, cannot but be impressed with the scope of the work and the remarkable uniformity of the results. As a piece of laboratory work, it is very excellent. Unfortunately, the investigator seems to have overlooked the fact that hydrated lime is a material having properties different from portland cement.

It is generally conceded by those who are familiar with hydrated lime admixed in concrete, and who have worked with it, that the maximum amount of water which should be used on its account, is only so much as will satisfy its absorptive qualities or properties. Absorptive is here used in its broad sense and may be divided into four heads, namely, absorption, adsorption, mechanically restrained and the possibility of a small amount being taken up by chemical action. Any additional water over and above that which lime can absorb, in the broad sense, particularly in the case of hydrated lime, is free water which is not restrained by the lime in any way; it merely goes to dilute the mixture. In the case of hydrated lime admixed with concrete, when more water is added than can be restrained by the lime, it goes to dilute the concrete; the lime cannot take care of it at all. It appears that this is one of the main points overlooked by the investigator.

He appears also to have overlooked the fact that lime hardens by an entirely different method than does portland cement. In the case of cement, there is a positive chemical reaction which takes place during the processes of setting and hardening. In the case of lime it must first dry out, or desiccate, and when the proper conditions as to moisture content are reached, it absorbs carbon dioxide from the air and is changed into crystallin calcium carbonate. It is well established that excess water with portland cement will have certain effects on the chemical reactions and the formation of the crystals resulting therefrom. Lime in the presence of excess water acts entirely differently. As long as lime is in the presence of excess water it remains merely a hydrated lime, or calcium hydroxide, in suspension, no chemical reaction taking place.

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[1] Construction Engineer, National Lime Association, Washington, D. C.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part II, p. 149 (1920).

[3] Discussion, Report of Committee C-7 on Lime, *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 302 (1921).

Water is added to a concrete of so-called "normal consistency" to produce the other "relative consistencies" such as 1.10, 1.25, etc. This is all right and we all recognize and acknowledge the effects of the water so added on the strength of the concrete so produced; thus, what we might term "the horizontal addition of water" to plain concretes is generally accepted and understood.

When hydrated lime is admixed with concrete, only enough more water should be added as can be cared for by the lime and this irrespective of the relative consistency of the concrete with which it is admixed. If, as previously pointed out, more than this amount of water is added it merely goes to further dilute the concrete and to make the consistency wetter than indicated.

It appears from the data presented that the amount of water used in the plain concrete specimens, and also in those containing hydrated lime, of so-called "normal consistency," was wrong.

On page 156 of the *Proceedings*, Vol. XX, Part II, it is stated: "A relative consistency of 1.00 or normal consistency is such as will give a slump of about ½ to 1 in." If now we look at Table XVI of the paper, which is a report of the slump tests, and consider only those of so-called "normal consistency," we find the following:

TABLE I.—SLUMPS, IN INCHES, OF CONCRETES OF SO-CALLED "NORMAL CONSISTENCY".

Hydrated Lime, per cent.	Mixes by Volume.					
	1 : 9	1 : 6	1 : 5	1 : 4	1 : 3	1 : 2
0	6.2	0.3	0.3	0.7	4.2	1.2
5	2.6	0.3	0.4	1.2	1.7	3.0
10	1.5	0.3	0.5	2.0	2.3	2.1
20	1.7	0.5	2.2	3.1	3.0	2.1
33	0.2	0.5	1.9	3.1	3.3	1.0
50	...	...	1.9	1.4	2.4	0.9

The criterion given by the investigator on page 156 of the *Proceedings*, Vol. XX, Part II, and previously quoted, is the accepted criterion. From the above tabulation it will be noted that but one of the six plain concretes meets the criterion. Of the twenty-eight results given for specimens containing hydrated lime but five meet the criterion, nineteen of them had greater slumps, averaging $2\frac{1}{4}$ in. If we assume that the proper amount of water was used in the specimens of so-called "normal consistency," it would appear from data given in the paper that the amount of water used to produce the concretes of other relative consistencies was wrong.

Again on page 156 of the *Proceedings*, Vol. XX, Part II, we find "Other 'relative consistencies' require a proportional part of the quantity of water necessary for normal consistency. For example, a relative consistency of 1.10 requires 10 per cent more water than normal consistency." Let us now turn to Table IV of the paper (pages 158–159 of the *Proceedings*, Vol. XX, Part II) and consider the plain concretes only. If we evaluate the water ratios of the several mixes as of "normal consistency" as being 100 and compute the relative values of the water ratios for the other "relative consistencies" on this basis the following is obtained:

TABLE II.—RELATIVE WATER CONTENTS OF PLAIN CONCRETE.

Mix, by Volume.	Relative Consistencies According to Column Headings.					
	0.90	1.00	1.10	1.25	1.50	2.00
1:9	92	100	109	122	...	...
1:6	91	100	109	122	...	...
1:5	90	100	108	122	144	188
1:4	90	100	108	122	144	189
1:3	90	100	109	122	145	192
1:2	90	100	109	123	148	195

Through the courtesy of the investigator, the water ratios used for the results recorded in Table I of the discussion to the 1921 report of Committee C-7 were supplied the speaker. When these water ratios are reduced as above, the following is obtained:

TABLE III.—RELATIVE WATER CONTENTS OF PLAIN CONCRETE.

Mix, by Volume.	Relative Consistencies According to Column Headings.				
	0.90	1.00	1.10	1.25	1.50
1:6	92	100	109	121	144
1:5	90	100	108	122	144
1:4	91	100	108	122	145
1:3	91	100	109	122	145
1:2	91	100	109	122	146

Bearing in mind the investigators own criterion, as quoted previously, it is evident that the relative water contents of the concretes of the several relative consistencies should correspond with the column heading. It will be seen that they do not. It will also be noted that the relative water content increases as the mixtures become richer, in many cases.

The amount of water added to compensate for the hydrated lime was wrong. It was added on a purely arbitrary and empirical basis and not in accordance with the method or procedure described. On page 304 of the *Proceedings*, Vol. 21, it is stated: "In general, the quantity of mixing water was predetermined. The quantity added to compensate for the presence of hydrated lime (or additional cement) was proportional to the quantity of hydrated lime (or cement) and to its normal consistency." Particular attention is here called to the part of the statement to the effect that the additional water was proportional to the normal consistency of the hydrated lime.

On page 153 of the *Proceedings*, Vol. XX, Part II, in speaking of hydrated lime, it is stated: "Normal consistency was determined by the Vicat needle by the method used for portland cement." The method of determining the normal consistency of lime paste by means of the Vicat needle is not reliable. It was discontinued several years ago by investigators of lime and a modified slump test substituted for it. The Vicat needle method depends on too many factors—all or any kind of results can be obtained with it; it depends upon whether the lime is added to the water or the water to the lime, on just how the mixing is done, and several other factors. One of the greatest factors is the length of time which elapses between the time the lime is first wetted and the time the needle on the apparatus is released. From Table III of the paper we find that it required 60 per cent of the *weight* of the hydrated lime, of water, to produce a paste of normal consistency by the Vicat needle test. Throughout all of the tables of the paper, relationships are given in terms of *volume*. By a simple calculation, the *weight* ratio of water required to produce a lime paste of so-called "normal consistency" can be changed into a *volume* ratio. By making such a calculation we find that the *volumes* of water required to compensate for the several percentages of hydrated lime, as of normal consistency, expressed as *water-cement* ratios are as follows: For 5 per cent hydrated lime admixture, the water ratio is 0.02; for 10 per cent, 0.04; for 20 per cent, 0.08; for 33 per cent, 0.13; and for 50 per cent, 0.19.

It would seem to have been a much more logical and proper procedure to have added lime to the concrete and then determined by means of the slump test, in the first series, or the flow table, in the supplementary tests, the proper amount of water to add to compensate for the lime. It is evident that the method used was purely arbitrary and empirical.

Let us now consider the method used to determine the amount of water added to compensate for the hydrated lime in the several relative consistencies other than normal consistency. As an example, let us consider the 1 : 4 mix from Table IV of the paper. Here, again, the water ratio for the plain concrete as of normal consistency has been evaluated at 100 and the other water ratios worked out to this basis:

TABLE IV.—RELATIVE WATER CONTENTS.

Hydrated Lime, per cent.	Relative Consistencies According to Column Headings.					
	0.90	1.00	1.10	1.25	1.50	2.00
0	90	100	108	122	144	189
5	92	103	111	125	150	195
10	96	105	115	129	153	200
20	100	111	121	136	161	212
33	106	118	128	144	172	225
50	114	126	139	156	185	242

It will be observed that the water ratios for the specimens with hydrated lime for the several relative consistencies were obtained, approximately, by *multiplying* the values given in column headed 1.00 by the relative figure for the plain concretes as of the several relative consistencies. For example, to get the relative water content for concrete of relative consistency 1.50 with 20 per cent admixture of hydrated lime, the value of 111 from column headed 1.00 was multiplied by 1.44 (approximately), the upper figure in column headed 1.50. From this it will be seen that for the several relative consistencies the water content was determined by *multiplication* instead of by *adding* water to compensate for the hydrated lime, in a constant quantity for each of the several percentages of hydrated lime, as clearly indicated in the quotation from page 304 of the *Proceedings,* Vol. 21, and as has been previously pointed out as being the proper method. The water content was uniformly increased as the mixtures became wetter for the specimens containing hydrated lime, and, as has been previously pointed out, this had the effect of diluting the concrete and making it wetter than indicated by the relative consistency column heading. It will be noted, for instance, that for 50 per cent admixture of hydrated lime, in column headed 1.00, 26 per cent more water was used than in the plain concrete, while in column headed 2.00 there was 53 per cent or more than twice as much extra water used. The multiplication factors used for each of the several mixtures were, approximately, the figures given in Tables II and III of this discussion. The facts shown above would seem to indicate that Conclusion 7 drawn by the investigator, namely, "The wetter mixes showed a greater loss in strength than the dry, due to the addition of hydrated lime" is hardly justified.

As the mixtures become richer, the actual water ratios of the plain concretes become less because less water had to be added on account of the absorption of the aggregates and the restraint of the aggregates. The same *actual* quantities of water were, however, added to the concretes, as of normal consistency, to compensate for the presence of the hydrated lime, therefore, as the *actual* water ratios of the plain concretes became less the ***relative*** amounts of water added to compensate for the hydrated lime became greater as is clearly shown by the following table, the data being taken from Table IV of the paper.

TABLE V.—RELATIVE WATER CONTENTS OF CONCRETES OF SO-CALLED "NORMAL CONSISTENCY."

Hydrated Lime, per cent.	Mixtures by Volume.					
	1 : 9	1 : 6	1 : 5	1 : 4	1 : 3	1 : 2
0	100	100	100	100	100	100
5	102	102	102	103	103	104
10	103	104	105	105	106	108
20	106	109	110	111	113	115
33	111	114	114	118	121	125
50	...	...	123	126	132	136

From this table, we see that in the 1 : 9 mix for 33 per cent admixture of hydrated lime there was but 11 per cent more water used, while in the 1 : 2 mix 25 per cent more was used or more than twice as much, relatively.

The above values are for the concretes of so-called normal consistency only. As has been previously pointed out the water contents of the concretes of other relative consistencies were obtained by *multiplying* the water-ratios of the concretes of normal consistencies by the relative water-ratios of the plain concretes of the several relative consistencies. In Table V it will be seen that the relative water content of the specimens containing hydrated lime increases as the mixtures become richer and from Table II that they also increase as the mixes of plain concrete become richer. Bearing in mind that the water contents of the specimens containing hydrated lime were obtained by *multiplying* the values given in Table V by those in Table II, the facts would hardly seem to justify Conclusion 6:

"Rich concrete mixtures showed a greater loss in strength due to powdered admixtures than the leaner ones. Lean mixes (1 : 9 to 1 : 6) and in those with aggregates graded too coarse for the quantity of cement used, the strength was little affected or was slightly increased by admixtures up to 50 per cent." A very cursory examination of Tables II and V will show why the 1 : 9 and 1 : 6 mixes were little affected.

The accompanying figures were plotted from data given in the tables of the paper either as presented or reduced to relative values as indicated in the tables presented with this discussion. They illustrate graphically the points indicated by the foregoing tables.

In Fig. 1, the upper set of figures shows the actual water ratios and the lower set, the relative water-ratios, both plotted against the relative consistencies and from data for mixes 1 : 9, 1 : 5 and 1 : 3 presented in Table IV of the paper. This figure shows clearly how the water added to compensate for the hydrated lime increased, relatively, as the mixes became richer and how the multiplication caused a very material increase in the relative water content as the mixes became of the higher relative consistencies.

If the strengths given in Table IV of the paper are plotted against the relative consistencies, a set of curves as shown in Fig. 2 is obtained. At first glance these curves would make it appear that hydrated lime has a deleterious effect on concrete, since all of the curves representing the several hydrated lime admixtures fall below the curves representing the plain concretes.

In several places, the author of the paper has published a formula of the form $S = \frac{A}{B^x}$ in which S is the strength which may be expected, x is the water-cement ratio used as an exponent and A and B are constants depending upon the materials used and the conditions of the test. The constants of this formula were evaluated for the data presented in the paper by working backwards. Using each of the plain concrete results given, in such tables as showed both water ratios and strengths, the values of A and B were determined; these several values were then averaged to obtain a general average value for A and B for general application.

The upper smooth curve shown in each of the six groups in this figure is the graphical representation of the evaluated strength formula for the plain concretes. The lower smooth curve is the corresponding curve for the specimens containing 50 per cent or 33 per cent of hydrated lime according to the maximum admixture used. When the

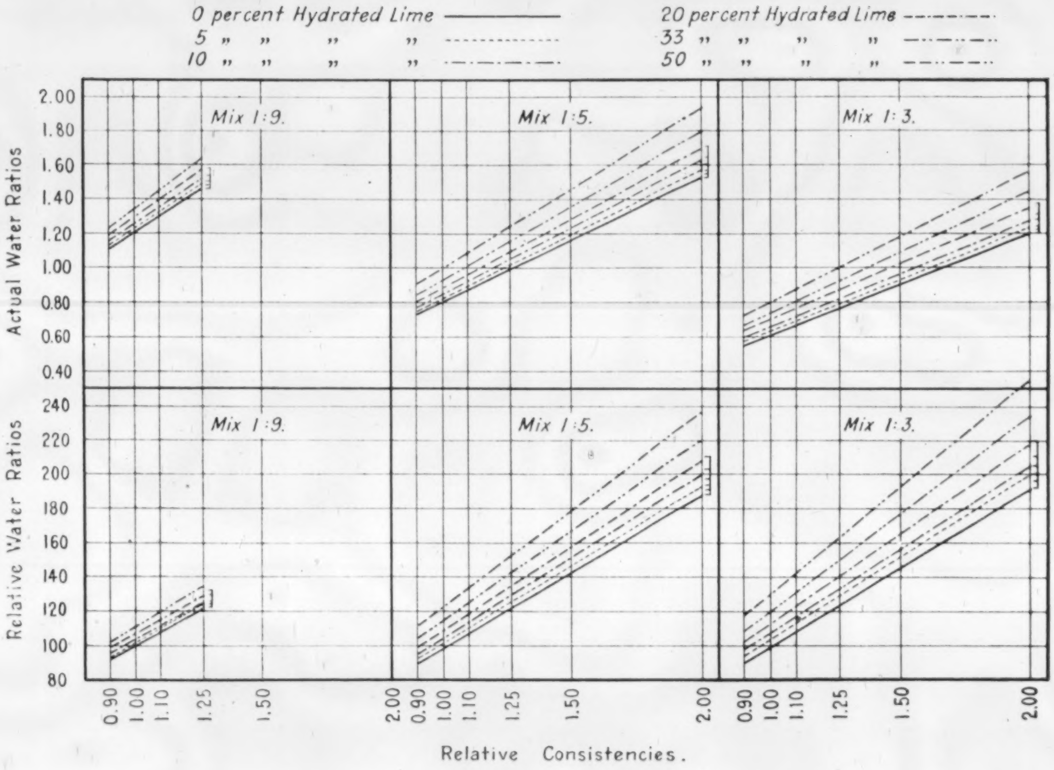

FIG. 1.—Actual and Relative Water Ratios Plotted Against Relative Consistencies.

The small comb-like figure at the right of each diagram indicates where the several curves would have terminated had the addition method been used instead of the multiplication method for determining the water to compensate for the lime.

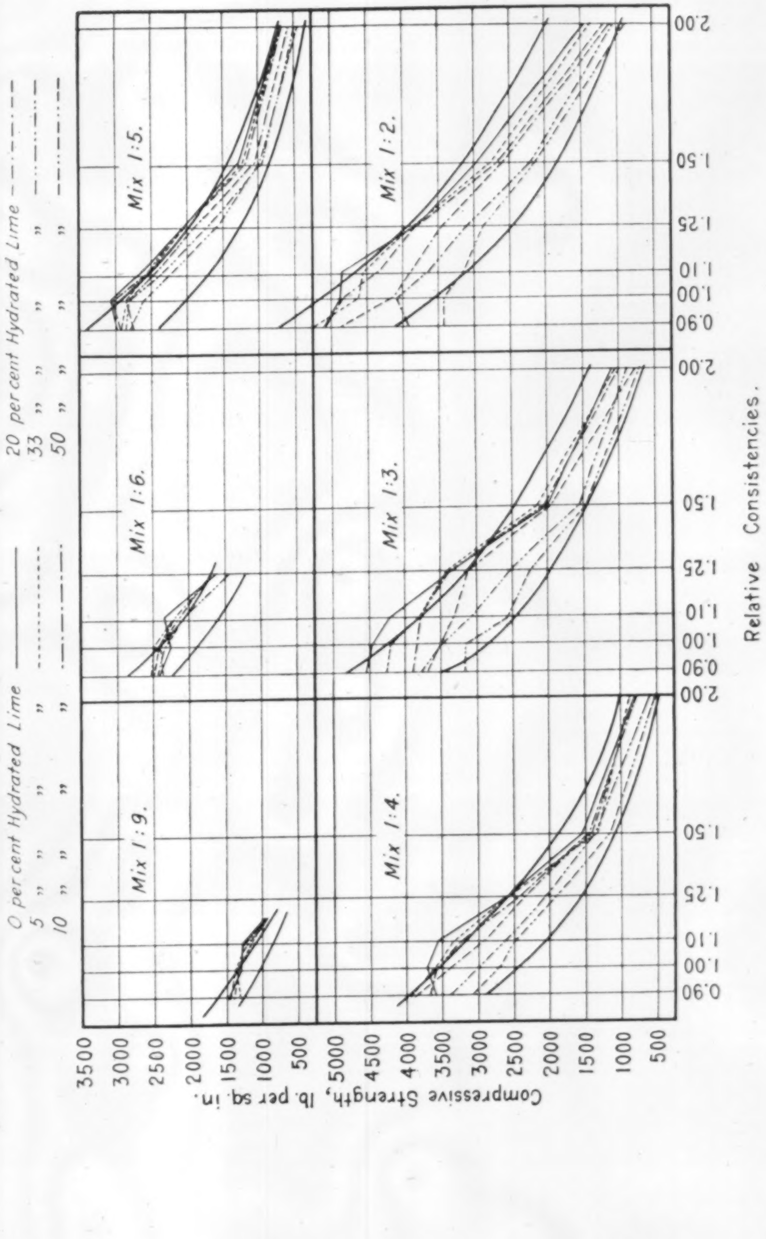

FIG. 2.—Strengths Plotted Against Relative Consistencies.

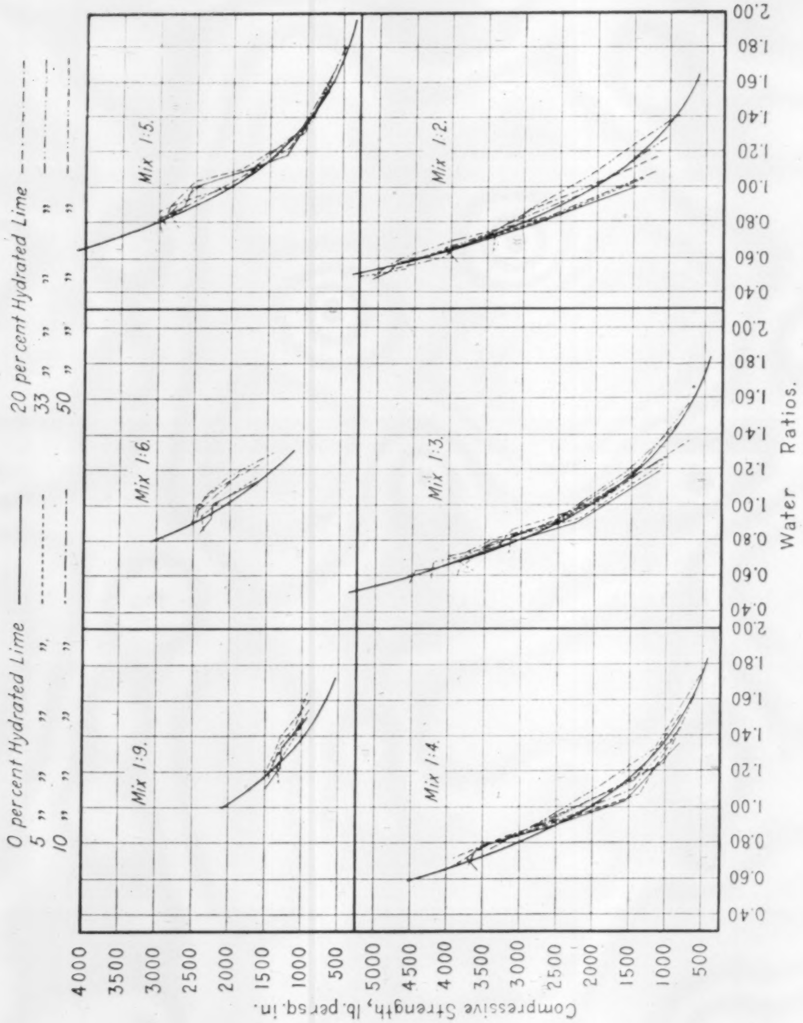

FIG. 3.—Strengths Plotted Against Water Ratios.

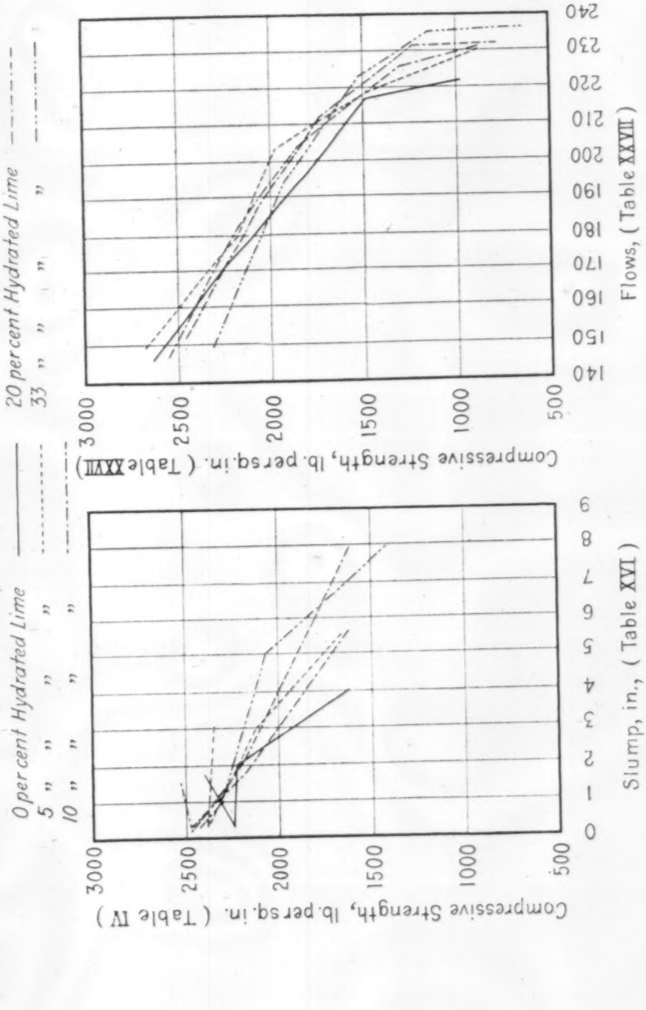

FIG. 4.—Strengths Plotted Against Slumps and Flows.

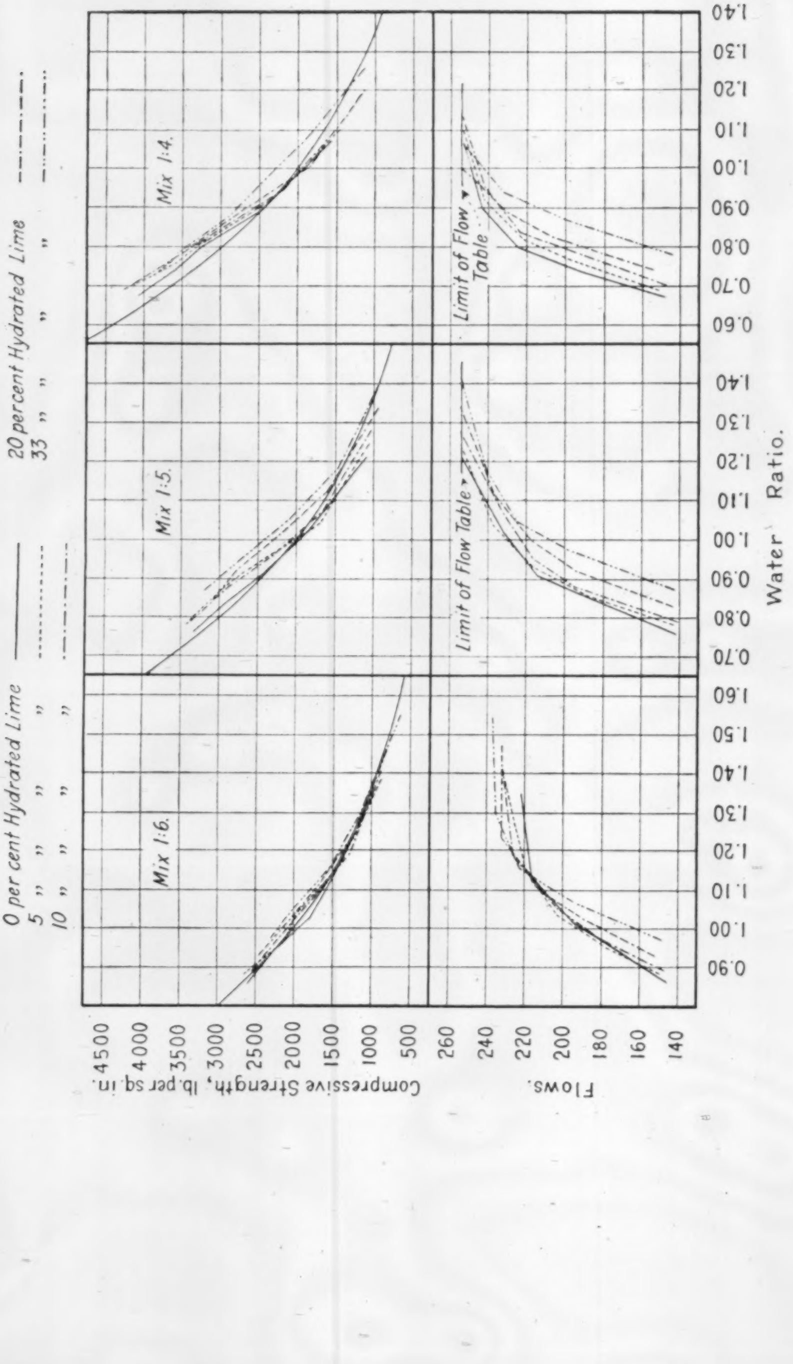

FIG. 5.—Strengths and Flows Plotted Against Water Ratios

plotted data are considered in connection with these theoretical strength curves, it will be observed that the presence of the hydrated lime had a decidedly beneficial effect and this in spite of the excessive amount of water used. Similar theoretical strength curves could have been shown for each of the hydrated lime admixtures, but by so doing the groups would have been unnecessarily complicated, the curves shown clearly bring out the principle involved and demonstrate the beneficial effects of the hydrated lime.

If the same data used in Fig. 2, from Table IV of the paper, is plotted as strength against water ratios, a set of curves as shown inFig. 3 is obtained. In these curves, the smooth curve is the theoretical strength curve plotted from the evaluated formula. These curves bring out strongly the fact that while the water ratios were increased, when the strengths were equal, that for equal water ratios the strengths were materially increased and this in spite of the fact that excessive water was used in most of the specimens containing hydrated lime.

Similar facts are shown by plotting the data of Table I of the discussion of the Report of Committee C-7 for 1921.[1]

Workability is, after all, the real criterion of the desirability or practicability of concrete. In Fig. 4 we have plotted the strengths against slumps for the 1 : 6 mix from data given in Tables IV and XVI of the paper, also strengths against flows, for the 1 : 6 mix, from data given in Table I of the discussion of the Report of Committee C-7 for 1921.[1] The reason for presenting the 1 : 6 mix is that it was the only one reported as staying within the limits of the flow table all the way through the tests and is, therefore, the only one for which a full comparison can be made. In spite of the extremely erratic nature of the data given in Table XVI, curves plotted for all of the mixtures, similar to the one here shown for the 1 : 6 mix, show results similar to those here shown. In like manner, plotting as much of the data from Table I of the discussion mentioned above as is significant results quite similar are shown.

These curves clearly bring out the facts that for equal strengths, the workability is increased, with very few exceptions, and for equal workability the strength is increased, with very few exceptions.

In the upper set of curves of Fig. 5 we have plotted strengths against water ratios from data as presented in Table I of the discussion of the Report of Committee C-7 for 1921 and supplementary data furnished by the author; in the lower set we have flows plotted against water ratios to the same scale. The smooth curves in the upper set represent the theoretical strengths derived from the author's strength formula. In the upper set we see that for equal strengths more water was used while for equal water ratios greater strength was developed. In the lower set we see that in most cases more water was used to obtain equal flows and that for equal water ratios the flows were less. This, of course, is to be expected since hydrated lime absorbs water. The 1 : 6, 1 : 5 and 1 : 4 mixes only have been shown for the reason that they are typical and showing more mixes would complicate the figure.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 305 (1921).

By means of these curves we can ascertain the true effect of hydrated lime admixtures on concrete. For instance, taking mix 1 : 5 and flow 210, we find that the water ratio for flow 210 used in the plain concrete was 0.90. By projecting the intercept of the 210 flow line with the plain concrete line, in the lower curve, upward to an intercept with the strength line, in the upper set, we find that the corresponding strength of the plain specimen is 2500 lb. per sq. in. In a similar way we find that the water ratio for the 5-per-cent admixture is 0.91 and the strength about 2700 lb. per sq. in.; again, in a similar manner, we find that for the 33 per cent admixture the strength is 2440 lb. per sq. in. which is well within the allowable laboratory variation and certainly does not show that the admixture of hydrated lime caused a falling off in the strength of the concrete and hardly substantiates the conclusions given in the paper. A large number of points have been run through on these curves in a similar manner and show that if the concrete was not improved as far as strength was concerned, that the variation in strength was well within the allowable limits of laboratory variation. The majority of points show an improvement in strength.

A complete mathematical analysis of the data contained in Table IV of the paper and in Table I of the discussion of the Report of Committe C-7 for 1921, computed by comparing the actual strengths reported for the several specimens with the theoretical strengths as determined from the evaluated strength formula, gives the results shown below. In scanning these tables it should be borne in mind that the strength formula was evaluated by taking the *average of all of the data given in all tables,* for the plain concretes. This fact will account for the apparent inconsistencies in the following summary:

DIFFERENCES IN COMPRESSIVE STRENGTH, LB. PER SQ. IN., OF DATA GIVEN IN PAPER AND STRENGTH AS COMPUTED FROM FORMULA.

Hydrated lime, per cent.	Mixtures.						Averages	
	1 : 9	1 : 6	1 : 5	1 : 4	1 : 3	1 : 2	Average of All Mixes.	Per 1 Per Cent Hydrated Lime.
DATA FROM TABLE IV.								
0	+ 15	− 80	− 48	−193	− 48	−295	−108	......
5	− 10	+ 12	− 60	+ 27	− 45	−212	− 48	(108−48) ÷ 5 = +12.0
10	+ 98	+162	+100	+ 72	− 17	−130	+ 48	+15.6
20	+190	+298	+125	+197	+ 27	− 60	+130	+11.9
33	+212	+355	+222	+143	+ 87	− 70	+158	+ 8.1
50	.....	.....	+350	+190	+ 50	− 33	+139	+ 4.9
Average, Hydrated Lime only	+122	+206	+147	+125	+ 20	−101	+ 85	+10.5
DATA FROM TABLE I OF THE DISCUSSION, REPORT OF COMMITTEE C-7, 1921.								
0	.....	− 44	− 22	+102	+100	+ 74	+ 42	......
5	.....	+ 6	+106	+204	+190	+104	+122	(122−42) ÷ 5 = +16.0
10	.....	+ 2	+ 96	+198	+216	+ 30	+112	+ 7.0
20	.....	+ 50	+170	+128	+122	− 92	+ 76	+ 1.7
33	.....	+ 54	+256	+232	+108	−102	+110	+ 2.1
Average, Hydrated Lime only	.....	+ 28	+157	+191	+159	− 15	+105	+ 8.7

RESULTS OF THE ANALYSIS OF ALL MIXTURES, ALL CONSISTENCIES, AND ALL PERCENTAGES OF HYDRATED LIME ADMIXTURES.

Hydrated Lime, per cent.	Net Effect on Strengths, lb. per sq. in.		Average Effect.	Per 1 Per Cent Hydrated Lime.		
	Table IV.	Table I. Discussion, 1921		Table IV.	Table I, Discussion, 1921	Average.
0	−108	+ 42	− 33	......	......	......
5	− 48	+122	+ 37	+12.0	+16.0	+14.0
10	+ 48	+112	+ 80	+15.6	+ 7.0	+11.5
20	+130	+ 76	+103	+11.9	+ 1.7	+ 6.8
33	+158	+110	+134	+ 8.1	+ 2.1	+ 5.1
50	+139	.....	.....	+ 4.9	......	......
Average, Hydrated Lime only	+ 85	+105	+ 95	+10.5	+ 8.7	+ 9.6

Analyzing all mixtures, all consistencies and all percentages of hydrated lime by comparison with the evaluated strength formula results we find that instead of "In usual concrete mixtures, each 1 per cent of hydrated lime (in terms of the *volume* of cement) reduced the compressive strength 0.5 per cent; 1 per cent by *weight* of cement reduced the strength 1.2 per cent. . . ." (Conclusion 2, page 201, *Proceedings*, Vol. XX, Part II) that as a matter of fact the strength was *increased* to the extent of 9.6 lb. per sq. in., on the average, for each 1 per cent of hydrated lime admixed and this in spite of the fact that the water to compensate for the hydrated lime was added on a purely arbitrary and empirical basis and in excessive amounts.

APPENDIX II.

EFFECT OF HYDRATED LIME ON THE STRENGTH AND FLOW OF CONCRETE.

By Warren E. Emley.[1]

For several years past, many investigators have been trying to ascertain whether or not the addition of hydrated lime to concrete is worth while. Their work has resulted in radically different conclusions. Since the integrity of the experimenters is above criticism, it must needs follow that there is a reason for these discrepancies.

To find this reason, 1600 specimens of concrete, with and without lime, and with varying amounts of water and different storage conditions, were tested for compressive strength and "flow." The results are shown in the curves given in Fig. 1. This work was done in cooperation with the Cement Section of the U. S. Bureau of Standards, Messrs. F. A. Hitchcock and J. R. Dwyer thereof being largely responsible for its planning and completion.

From these curves, the following general truths are obvious:

1. If water, but no lime, is added to a given concrete, the flow will be *increased* and the strength *decreased*.

2. If lime, but no water, is added to a given concrete, the flow will be *decreased* and the strength *increased*.

These statements bear out the results obtained by other investigators. They are perfectly obvious from the curves, which show them to hold practically without exception.

It follows as a logical corollary to the above conclusions that if both lime and water are added to a given concrete, the effect on both the strength and the flow may be plus, minus, or zero, depending upon the numerical values of the factors involved. These factors are three: The character of the given concrete, the change due to the lime, and the change due to the water.

The value of the first factor will depend upon whether the given concrete is wet or dry, rich or lean, and upon the nature and proportions of the aggregate. Any change in this factor may easily mask the effect of the other two. Failure to allow for this point is probably the cause of the noted discrepancies found by different investigators.

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[1] Chemist, U. S. Bureau of Standards, Washington, D. C.

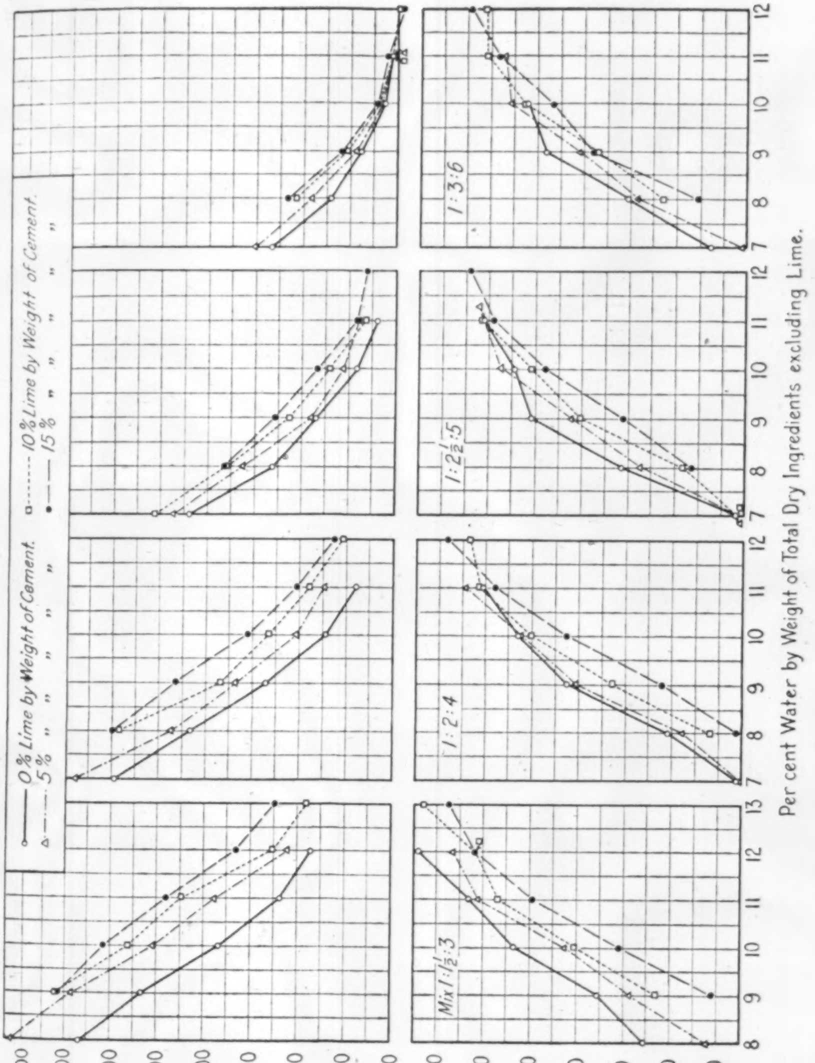

FIG. 1.—Effect of Hydrated Lime on Concrete.

All compressive tests made on 3 by 6-in. cylinders, at age of 28 days. Stored in moist air.

To illustrate the conclusions given above, as well as the method of using the curves, the following examples have been selected:

1. Given a 1 : 2 : 4 concrete, 8.05 per cent of water (this has a flow of 150 and a strength of 2100 lb. per sq. in.), to determine the effect on the strength if lime is added with enough water to keep the flow constant:

LIME, PER CENT.	WATER, PER CENT.	STRENGTH, LB. PER SQ. IN.	FLOW.
0	8.05	2100	150
5	8.3	2130	150
10	8.6	2250	150
15	9.15	2200	150

2. Given a 1 : 1½ : 3 concrete, 9.05 per cent of water (this has a flow of 172 and a strength of 2500 lb. per sq. in.), to determine the effect on the flow if lime is added with enough water to keep the strength constant:

LIME, PER CENT.	WATER, PER CENT.	STRENGTH, LB. PER SQ. IN.	FLOW.
0	9.05	2500	172
5	9.85	2500	176
10	10.3	2500	187
15	10.65	2500	183

In both of the above examples, the addition of 10 per cent of lime is apparently beneficial, but the effects are within the probable experimental error. This fact may be emphasized by a third example:

3. Given a 1 : 2½ : 5 concrete, 9 per cent of water (this has a flow of 202 and a strength of 1007 lb. per sq. in.), to determine the effect on the strength if lime is added, with enough water to keep the flow constant:

LIME, PER CENT.	WATER, PER CENT.	STRENGTH, LB. PER SQ. IN.	FLOW.
0	9	1007	202
5	9.55	997	202
10	9.95	997	202
15	10.2	1000	202

Obviously, such examples could be repeated indefinitely, but enough have been cited to warrant the following conclusions:

The effect of hydrated lime on concrete will depend first of all on the properties of the concrete, whether wet or dry, rich or lean, on the nature of the aggregate, etc.

The effect of the addition of lime and the effect of the addition of water will be in opposite directions. The net effect when both are added will be an algebraic sum, and may be plus, minus, or zero, depending upon the relative magnitudes of the effects of each, acting separately. This in turn will depend, not only on the amounts of lime and of water, but also on the properties of the original concrete.

From the above discussion, it is seen that the effect of hydrated lime on the strength and flow of concrete depends somewhat on the amount of lime added, somewhat on the amount of water added to compensate for the lime, but chiefly upon the initial character of the concrete to which the lime and water are added.

On the assumption that the flow table is the best present method for measuring the workability of concrete, it would seem fair to compare the strength of concretes having equal flow. However, the Bureau has long recognized the limitations of the flow table, as shown by the increase in irregularity of the flow curves as the mixes become of a more segregating nature. We are continuously striving to devise some modification of the flow test that will differentiate between mixtures having the same flow but of varying quantities of component materials, which in themselves affect the workability.

APPENDIX III.

INVESTIGATION OF EFFECT OF HYDRATED LIME IN CONCRETE.

BY H. F. CLEMMER.[1]

The variety of opinions of engineers on the effect of hydrated lime in concrete has led the Bureau of Tests of the Illinois Division of Highways to conduct tests with this material in an effort to arrive at definite conclusions in regard to its usage. The tests as conducted were expected to furnish information regarding the effect of hydrated lime on the strength of concrete in which sands of different fineness were used, and also the effect of the material in stabilizing the moisture content of the concrete.

The coarse aggregate used in making the specimens for this investigation was kept constant in every case, but the fine aggregate consisted of two sands of different finenesses. Both sands were divided on a 20-mesh sieve and in one set of the specimens the sand was reproportioned 50 per cent by volume passing the 20-mesh sieve and 50 per cent retained on the sieve. In the other set the volumetric proportion was 76 per cent passing and 24 per cent retained on the 20-mesh sieve.

All materials were proportioned by weight but conformed with the state standard volumetric mix of 1 : 2 : $3\frac{1}{2}$. The constancy of the consistency was determined by the flow table method. The water was weighed for each batch and the water-cement ratio determined in every case. This ratio was kept exceptionally uniform in the construction of the specimens.

The specimens consisted of 48 beams, 8 by 12 by 30 in., for transverse tests, and 100 cylinders, 6 by 12 in., for compression tests. The specimens were broken at the end of 30 and 60 days.

The following tables show the results obtained from the specimens made up with the different sands and containing the various percentages of hydrated lime:

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[1] Engineer of Tests, Illinois Division of Highways.

		At 30 Days.		At 60 Days.		
Lime, per cent.	No.	Modulus of Rupture, lb. per sq. in.	Compressive Strength, lb. per sq. in.	Modulus of Rupture, lb. per sq. in.	Compressive Strength, lb. per sq. in.[a]	Compressive Strength, lb. per sq. in.[b]
			Coarse Sand.			
0	HL-1	622	2 992	755	3 710	3 892
2½	HL-2	583	3 002	736	3 650	3 853
5	HL-3	621	3 664	793	4 175	4 748
7½	HL-4	581	3 489	693	3 745	3 678
			Fine Sand.			
0	HL-8	605	2 978	643	3 837	3 910
2½	HL-5	575	3 354	747	3 733	3 833
5	HL-6	573	3 752	633	3 700	3 503
7½	HL-7	558	2 971	682	3 728	3 390

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[a] 60 days damp sand storage.

[b] 30 days damp sand, 30 days in air.

The results as shown by the above tables indicate that the difference in transverse strength between the specimens containing the hydrated lime and those in which no lime was incorporated is very slight, so small that it cannot be considered as a real difference due to the presence of the lime. This is also the case with the specimens containing the fine sand and the coarse sand as very little difference in modulus of rupture is noted.

In the compression tests there is an indication that 5 per cent of the hydrated lime used with concrete containing coarse sand increases the strength to some extent. In the specimens containing the fine sand, however, the hydrated lime appears to decrease the compressive strength of the concrete.

The investigation of the stabilizing effect of hydrated lime on the moisture content of the concrete consisted of placing plain and lime incorporated concrete beams under the same conditions of alternate wetting and drying and observing the resulting movements by the use of the Berry strain gage. No conclusions on the results of these tests have been formed up to the present time as the investigation is still in progress. It is also the intention of the Bureau of Tests to study both the high calcium limes and the magnesium limes before completing these tests.

A more thorough investigation on the effect of hydrated lime in concrete is now being outlined and will probably be undertaken within a short time. The results of this investigation will undoubtedly be of greater value than any of the tests conducted to date in this type of study by the Illinois Highway Department.

APPENDIX IV.

EFFECT OF HYDRATED LIME ON STRENGTH AND FLOW OF CONCRETE.

By H. C. Berry.[1]

The results here presented are those of tests of 6 by 12-in. concrete cylinders, made in the testing laboratory of the University of Pennsylvania. The original series was planned to show the comparative strengths of different concrete aggregates. To this we added 120 cylinders, to half of which lime was added equal to five per cent of the weight of the cement, and to the other half ten per cent of lime was added. The results of specimens from the larger series were used for comparison for zero per cent of lime. Two coarse aggregates, $\frac{3}{4}$-in. gravel and $\frac{3}{4}$-in. crushed stone, were used. The cement was a mixture of four standard brands. The fine aggregate was yellow river sand, locally known as Jersey gravel, having a fineness modulus of 3.4. The fineness modulus of the $\frac{3}{4}$-in. gravel was 6.9; of the $\frac{3}{4}$-in. crushed trap rock, 7.4. The proportions were 1 : 2 : 4 and 1 : 2½ : 5, by volume. Two consistencies were studied: a dry consistency, in which enough water was used to obtain a flow of 165 on a flow table which is essentially like the one at the U. S. Bureau of Standards, and a wet consistency, which gave a flow of 190.

All specimens were mixed by hand in single specimen batches. The specimens were stored in damp sand and tested at 28 days, being taken from the sand two days before the test was made. They were carefully capped and tested with a spherical compression block, having an angle attached so as to make it self-centering. The load was applied at a continuous rate, the downward motion of the testing machine head being about 0.05 in. per minute. The deformations were taken and plotted semi-automatically.

The specimens were made and tested by recent graduates of the Civil Engineering Department who had practiced continuously in the laboratory for about three weeks before making up the specimens containing lime in this series. The average results are given in Table I. These may be studied best from examination of their respective locations on a diagram similar to that shown in Fig. 1 of Appendix II. As Mr. Emley has shown in this figure, they indicate that if both water and lime are added to the same batch, as compared with an exactly otherwise similar batch, the strength of the second one may be made either greater or less. His curves show if lime is added and water kept constant the strength is increased, and the flow table number decreased. In this series the flow was kept constant, but because of the addition of the lime the water percentage had to be varied. Hence, it is not conclusively shown by an examination of the table whether the lime increased or decreased the strength of the concrete. In six of the eight cases where lime was added to the concrete of rich proportion, the strength was materially increased over that of corresponding plain concrete. Due to the addition of the lime, more water was needed to obtain the same flowability, this water, of course, having a tendency to decrease the strength of the concrete, yet, since in six of the eight cases the strength is actually greater, we must conclude that the lime does not decrease the strength of the concrete but adds to it. The same conclusion holds for the concrete of the leaner mix, since, again, in six of the eight possible cases there is a greater strength for those mixtures to which lime was added. The percentage of increase for the six cases is slightly greater for the lean concrete than for the richer, again tending to show that the addition of lime has no harmful effect on the strength of the concrete.

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[1] Professor of Materials of Construction, University of Pennsylvania.

TABLE I.—RESULTS OF TESTS AT UNIVERSITY OF PENNSYLVANIA ON EFFECT OF HYDRATED LIME ON STRENGTH OF CONCRETE.

Hydrated Lime, per cent.[1]	1 : 2 : 4 Mix.				1 : 2½ : 5 Mix.			
	Dry, 165 Flow Table.		Wet, 190 Flow Table.		Dry, 165 Flow Table.		Wet, 190 Flow Table.	
	Water, per cent.[2]	Compressive Stress, lb. per sq. in.	Water, per cent.[2]	Compressive Stress, lb. per sq. in.	Water, per cent.[2]	Compressive Stress, lb. per sq. in.	Water, per cent.[2]	Compressive Stress, lb. per sq. in.
AGGREGATE: ¾-in. GRAVEL.								
0	7.8	2 673	8.9	2 016	7.5	1 957	8.3	1 631
5	8.5	2 338	8.9	2 338	8.3	1 865	8.35	1 716
10	8.9	2 340	9.3	2 340	8.2	1 822	8.3	1 914
AGGREGATE: ¾-IN. CRUSHED STONE.								
0	8.7	2 842	9.4	2 049	7.6	1 842	8.1	1 505
5	8.9	2 889	10.0	2 842	8.25	2 116	8.6	2 248
10	9.5	3 021	10.0	2 540	8.6	2 022	9.1	2 384

[1] Percentage of weight of cement.
[2] Percentage of weight of dry materials excluding lime.

DISCUSSION.

Mr. Abrams. Mr. D. A. Abrams (*by letter*).—Mr. Shertzer's discussion (Appendix I) is devoted to a detailed criticism of tests carried out under my direction. Our experimental studies of the effect of hydrated lime and other powdered admixtures on the strength and other properties of concrete included over 20,000 tests and were probably the most comprehensive that have been undertaken. They extended over about 5 years and were made in the light of over a dozen years' experience in tests of cement, concrete and other materials of construction. In these tests we introduced all the refinements then known to the art of concrete testing, many of which owed their origin to the work of this laboratory. Mr. Shertzer comments on the "remarkable uniformity of the results."

It is apparent to anyone that hydrated lime has different properties from portland cement. The only assumption made in our tests was that the quantity of mixing water should be increased in proportion to the quantity and normal consistency of the hydrated lime. The normal consistency of hydrated lime was determined in the same manner as for the cement. This seems to be an entirely reasonable procedure, since the lime must combine in a mixture which is plastic in the same way as the cement. The same method was used for 17 other powdered admixtures which were included in our tests. The fact that cement later hardens due to chemical combination with the water has no bearing on the question of workability of the concrete.

Mr. Shertzer states: "It is generally conceded by those who are familiar with hydrated lime admixed in concrete, and who have worked with it, that the maximum amount of water which should be used on its account, is only so much as will satisfy its absorptive qualities, or properties. Absorption is here used in its broad sense and may be divided into four heads, namely, absorption, adsorption, mechanically restrained and the possibility of a small amount being taken up by chemical action." He does not here state how much water is absorbed by hydrated lime (no comments are made on the unusual liberties in the matter of definitions); fortunately, however, he has given his views in a discussion before the City Paving Conference, Philadelphia, October, 1921, in these words: "Hydrated lime has the property of absorbing its own weight, or more, of water."[1]

Assuming that Mr. Shertzer uses the word "absorb" in the same sense in both discussions, we find that he would allow nearly twice

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[1] *Canadian Engineer*, January 3, 1922, p. 111.

Mr. Abrams. the amount of water for the lime that was added by us. According to our test methods, to which Mr. Shertzer objects, the water added on account of the lime was on the basis of a normal consistency of 60 per cent (or less) by weight. (See Table III of our paper.)

Mr. Shertzer's objections to the use of the Vicat needle for determination of the normal consistency of lime has no proper basis; this method is satisfactory for cement and there appears to be no reason why it should not be used for lime to be mixed with cement. It is an interesting fact that the normal consistency *by volume* is practically constant for the 18 powdered admixtures used in our tests, although the values *by weight* varied from 8.4 per cent for ironite to 230 per cent for kieselguhr. This uniformity of results for materials of the greatest variety seems to be a strong argument in favor of the use of the Vicat needle for this purpose. (I do not venture an opinion of the suitability of this test for lime for other purposes.) The Standard Specifications and Tests for Portland Cement of this Society indicate the exact method to be followed in all the details of the normal consistency test, hence all the pitfalls listed by Mr. Shertzer were avoided.

The statements regarding the chemical action of lime and cement are both erroneous. It is beside the point to assume that lime absorbs "carbon dioxide from the air and is changed into crystallin calcium carbonate" when these tests were in general made on *damp* concrete at the age of 28 days or less. It is well known that lime does not carbonate for years or even centuries, unless it becomes dry and has free access to air. There is little or no evidence to prove that the hydration of portland cement is in any way affected by the quantity of mixing water used, so long as there is sufficient water to satisfy the chemical requirements of the cement—probably not more than 25 to 30 per cent of the water in ordinary concrete mixtures. The evidence shows that each particle of cement hydrates regardless of the quantity of water. However, in the case of concrete with an excess of mixing water, the cement particles are so dispersed and the resulting solution is so diluted that it is greatly weakened as compared with a concrete mixed to normal consistency.

Mr. Shertzer objects to our method of multiplying the quantity of water required by a relative consistency of 1.00 in order to secure other consistencies, on the ground that a constant quantity of water should have been added regardless of the relative consistency of the concrete. It was our purpose to obtain a *graduated* series of consistencies, and in doing so, the hydrated lime was treated exactly in the same manner as other materials in the batch.

Mr. Abrams. Mr. Shertzer calls attention to differences between the values in our Table XVI and the slump required by our definition of normal consistency. It would readily be found by anyone who makes a few slump tests that this test cannot be interpreted too strictly. The slump test was not depended upon for determining the quantity of mixing water; the quantity was determined by calculation and the slump recorded as a rough measure of workability.

In his Tables II and III of his discussion, Mr. Shertzer notes slight discrepancies between the relative consistencies and the relative water contents. His confusion arises from the fact that we recorded the total quantity of mixing water added to the batch, without correction for absorption of water by the aggregate. It is obvious that it is proper to make such a correction. Except for the wetter mixtures, the total discrepancy to which he calls attention represents a variation of *not more than 2 per cent*, which would not appreciably affect the strength.

Mr. Shertzer claims it would have been more logical to have determined the proper quantity of mixing water in the concrete by use of the slump or flow test. As pointed out above, the slump test is not sufficiently refined to warrant such a procedure, especially when studying the effect of small quantities of lime. The flow test is more accurate and was used in tests in Group 4 of our Table III (*Proceedings*, Vol. 21, p. 305). These tests are shown graphically in our Figs. 4 and 5. In Fig. 5 the data are compared with data from Group 1 in which the quantity of water was predetermined by calculation. This diagram shows the quantity of mixing water used, compressive strength and flow. It will be noted that there was little difference in the results secured by the two methods.

In his Table IV, Mr. Shertzer gives the quantities of water for the 1 : 4 mix from our Table IV (*Proceedings*, Vol. XX, p. 158) expressing it as percentages of the water used for concrete without lime and a relative consistency of 1.00. He states: "for 50 per cent admixture of hydrated lime in column headed 1.00, 26 per cent more water was used than in the plain concrete, while in column headed 2.00, there was 53 per cent, or more than twice as much extra water used." It should be pointed out that (1) twice as much water was added for *each* of the materials in the concrete (the hydrated lime was treated the same as other materials); (2) while it is true that 53 per cent more water was used for concrete having a relative consistency of 2.00 and 50 per cent lime than for concrete having a relative consistency of 1.00 and no lime, only 26 per cent more water was used than for concrete of *similar* consistency with no lime. In other words, the quantity of

Mr. Abrams. water attributed to hydrated lime was increased in the *same proportion* for all consistencies. Hence it is seen that the values in Table IV are entirely beside the point and exhibit a lack of understanding of the principles involved.

He cites data from our Table IV to show that while the same amount of water was added to account for the lime for all mixtures, relatively less water was added for the lime in the leaner mixtures. On this basis Mr. Shertzer objects to our Conclusion 6, "Rich concrete mixes showed a greater loss in strength due to powdered admixtures than the leaner ones. Lean mixes (1 : 9 to 1 : 6) and in those with aggregates graded too coarse for the quantity of cement used, the strength was little affected or was slightly increased by admixtures up to 50 per cent." He states that "A very cursory examination of Tables II and V will show why the leaner mixtures were little affected." It is obvious that the relative quantity of water added to the concrete due to hydrated lime would be greater in the richer mixtures than in the leaner ones, since the richer mixtures contain a greater volume of lime. Mr. Shertzer seems to have fallen into the error of assuming that lime requires different quantities of water for a given plasticity, depending on the nature of the concrete in which it is used. Our tests show this is not the case.

In Fig. 1, Mr. Shertzer puts in graphic form his opinion of the quantity of water which we should have used to take care of the lime. This point needs no further discussion, except to reiterate that we wished to secure concretes of a graduated series of consistencies, and that the hydrated lime was treated in exactly the same manner as the other ingredients.

In Figs. 2 and 3, Mr. Shertzer has plotted data from our Table IV showing the relation between relative consistency and compressive strength of concrete for different percentages of lime. This diagram contains curves drawn from values calculated from a water ratio-strength relation of the form $S = \frac{A}{B^x}$. These curves are said to be based on our tests of "plain concrete." Apparently $A = 14,000$ and $B = 7$ were the values obtained. Using the formula based on concrete *with no lime,* he calculates "S" for water ratios of concrete containing 33 or 50 per cent of hydrated lime "according to the maximum admixture used." This relation is shown in the lower smooth curves. He states: "When the plotted data are considered in connection with these theoretical strength curves, it will be observed that the presence of the hydrated lime considered in connection with the data had a decidedly beneficial effect and this in spite of the excessive amount of water

Mr. Abrams. used." A correct interpretation of the diagram shows no such thing. The series of "theoretical curves" in Fig. 2 *have no direct bearing* on effect of lime on the strength of concrete. These diagrams represent a mere juggling of figures. Mr. Shertzer has failed to point out in what way they show "a decidedly beneficial effect" for lime and it seems unlikely that the casual reader could reconstruct his line of thought. What Mr. Shertzer probably intends the reader to infer is that our test data show that concrete containing lime give values higher than those for similar concrete without lime. However, he has failed to point out the very obvious reason for the relation shown in these diagrams.

Concrete made with the *same quantity* of water gives higher strengths (and the concrete is less workable) if hydrated lime is added, due to the fact that a portion of the water goes to wet the lime and consequently does not influence the concrete strength in the same way that an equal quantity of water would be expected to do under usual conditions. This is an elemental consideration concerning which no mistake should have been made, especially since this very point was discussed in our original report in the following words referring to a diagram of the same kind: "These curves bring out the water ratio-strength relation for different conditions, but *do not show directly the effect of hydrated lime on the strength of concrete.*" (*Proceedings*, Vol. XX, Part II, p. 172.) *The relative plasticity of the concrete must be taken in account before true effects can be shown.* The following example was given in order that no one should mistake the proper interpretation of the figure:

> "The water ratio of 1 : 4 mix, relative consistency 1.10, with aggregates of fineness modulus 5.75, without hydrated lime is 0.78; with 50 per cent hydrated lime it is 1.00. The strength in the first instance is 3100 lb. per sq. in., while with the 50 per cent hydrated lime it is 2400 lb. per sq. in."

The same error was made by one of Mr. Shertzer's collaborators in his criticisms of our tests and has already been corrected by me in two different publications; see *Proceedings*, Vol. XX, Part II, 1920, p. 217, and *Engineering News-Record*, December 30, 1920, p. 1297.

The effect of adding lime to concrete *without* changing the quantity of mixing water is clearly shown in our Table XII, *Proceedings*, Vol. XX, Part II, 1920, and Table III, *Proceedings*, Vol. 21, 1921. Table III also shows the decrease in the plasticity as measured by the flow table. The data from this table are repeated in our Fig. 4. The method by which the water was assigned to the various constituents of the concrete has no bearing on the position of the diagrams in which strength is plotted against water ratio. It should be noted

Mr. Abrams.

also that Mr. Shertzer has based his comparisons on a "general average value," which may not be representative of values in a given series of tests; we may expect somewhat different water ratio-strength relations from tests made over a considerable period of time.

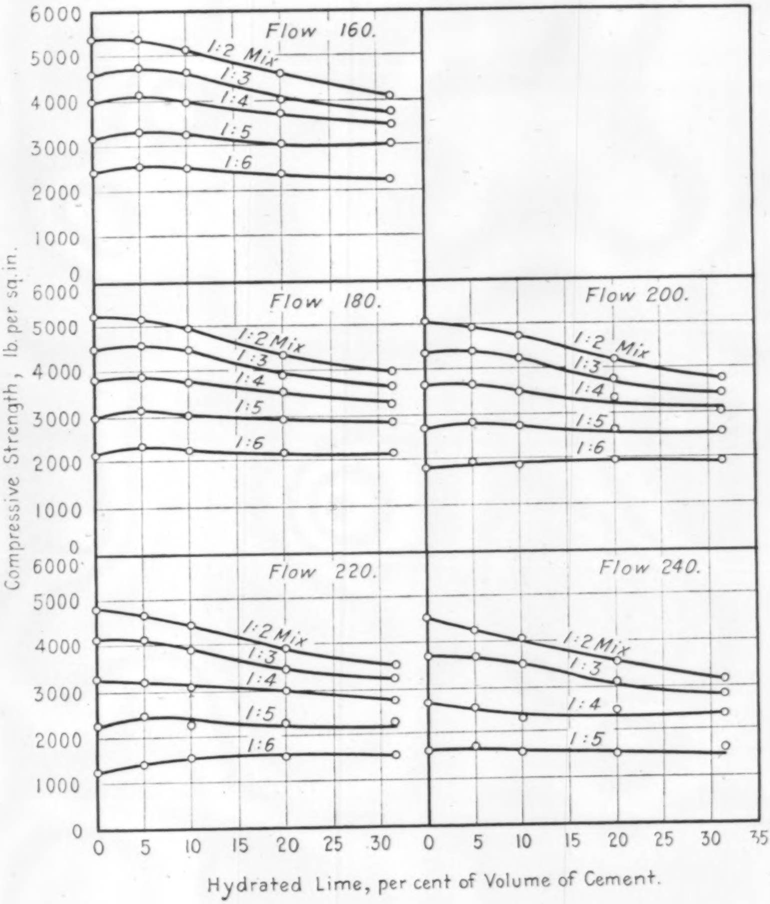

FIG. 1.—Effect of Hydrated Lime on the Strength of Concrete.

Based on data in Table I, *Proceedings*, Vol. 21, 1921, p. 305.
Compression tests of 6 by 12-in. concrete cylinders.
Mix by volume.
Cement: a mixture of 4 brands of portland cement, purchased in Chicago.
Aggregate: Sand and pebbles from Elgin, Ill., graded 0–1½ in. (fineness modulus, 5.75).
Results based on tests of 10 specimens for each condition, tested on different days.
Specimens stored in moist room until test; tested damp at age of 28 days.

In Fig. 4, Mr. Shertzer points out that for a 1 : 6 mix the strength of concrete is little affected or slightly increased by the addition of

Mr. Abrams. hydrated lime. This fact is clearly shown in our reports and attention is called to it in our Conclusion 6. Had Mr. Shertzer plotted similar diagrams for the usual mixtures he would not have found this beneficial effect. Fig. 1 has been prepared from tests in our Series 147 (*Proceedings*, Vol. 21, p. 305, Table I), it is similar to our Fig. 2 in the above report, except that the curves are plotted for *constant flow*, rather than for constant consistency. For the 1 : 6 mix the strength is seen to be little affected or slightly increased by additions of hydrated lime up to 33 per cent of the volume of cement. For the richer mixtures, the trend of the curves shows a decrease in strength with the addition of lime.

While Mr. Shertzer's Fig. 5 can be used to determine the effect of hydrated lime on concrete, it is arranged in such a manner as to give an erroneous impression unless the diagrams are studied with care. His curves for concrete containing lime are in general above those without lime; however, he fails to emphasize the fact that the points lying on a given vertical ordinate, represent *different consistencies*, and consequently that the differences in strength result from absorption of water by the lime. Mr. Shertzer has worked out two examples to illustrate the use of this diagram for comparing concrete of equal flowability. Our Fig. 1, discussed above, has been prepared from the same data and shows directly the effect of lime.

The burden of Mr. Shertzer's discussion hinges on the fact that if lime is added to concrete without increasing the quantity of mixing water to compensate for the lime, the strength is increased. He chooses to ignore differences in plasticity of concrete which naturally result from this procedure. This erroneous interpretation has been made in spite of the following:

1. Earlier in his discussion he points out in detail the factors which affect the water requirements of lime in concrete.
2. The statements in our report should have prevented an erroneous interpretation of the tests.
3. We have repeatedly corrected the same error made by earlier critics of our tests.

His statement that "Analyzing all mixtures, all consistencies and all percentages of hydrated lime by comparison with the evaluated strength formula results we find . . . . that as a matter of fact the strength was increased to the extent of 9.6 lb. per sq. in., on the average, for each 1 per cent of hydrated lime admixed," is true only by virtue of the clause "by comparison with the evaluated strength formula," while as a matter of fact no proper comparison can be made on this basis, due to the obvious differences in plas-

Mr. Abrams. ticity discussed above. A correct interpretation of the tests shows an average *decrease* for *all mixtures and consistencies* of 14 lb. per sq. in. for each 1 per cent of hydrated lime (by volume) for data in our Table IV (*Proceedings*, Vol. XX, Part II, 1920) and a decrease of 9 lb. per sq. in. for data in our Table I (*Proceedings*, Vol. 21, 1921). On the other hand, the addition of 1 per cent of cement *increased* the strength of concrete 1 per cent, or about 25 lb. per sq. in. for the usual concrete mixtures. The values from Table IV are based on concrete of the *same consistency* as measured by the flow table.

After a thorough review of our reports and careful consideration of all points raised by Mr. Shertzer, we find no reason for modifying our original conclusions with reference to the effect of hydrated lime in concrete, one of which was: "In usual concrete mixtures each 1 per cent of hydrated lime (in terms of volume of cement) reduced the compressive strength 0.5 per cent; 1 per cent by weight of cement reduced the compressive strength 1.2 per cent."

The two "general truths" stated by Mr. Emley have long been obvious (when applied to plastic concrete), as was fully shown by tests carried out in this laboratory two to four years ago. It is apparent that the proper balance between the quantity of lime and the quantity of mixing water added because of the presence of the lime is the basis of the effect of hydrated lime on the strength of concrete.

Our tests which cover the same ground as Mr. Emley's are:

Series 147, Group 1, (1920) 1300 compression tests of 6 by 12-in. concrete cylinders at age of 28 days; mixes 1 : 6 to 1 : 2; 5 different consistencies; hydrated lime in quantities ranging from 0 to 33 per cent of the volume of cement; flow tests made on all batches.

Series 147, (1920) compression tests of 6 by 12-in. concrete cylinders, 1 : 5 and 1 : 4 mixes at age of 28 days; hydrated lime or portland cement up to 33 per cent in addition to the initial quantity of cement, for two conditions:

1. Mixing water constant, regardless of quantity of admixture (variable flow);
2. Flow constant (mixing water varying with quantity of admixture).

Series 114, (1918), compression tests of 6 by 12-in. concrete cylinders, 1 : 5, 1 : 4, and 1 : 3 mixes, using hydrated lime ranging from 0 to 50 per cent of volume of cement; *constant quantity of mixing water* for a given mix.

The results of these tests are given in full in *Proceedings*, Am. Soc. Test. Mats., Vol. 21, 1921, pp. 305 and 308, and Vol. XX, Part II, 1920, p. 176.

Mr. Abrams. It is impossible to arrive at any conclusion as to the value o Mr. Emley's tests, since no information is given regarding the size and grading of the aggregate, the methods of mixing the concrete, sequence of making specimens, etc., or the number of tests included in each point on the diagram. Mr. Emley states that the effect of hydrated lime depends on the "character of the given concrete," "on the properties of the concrete," "on the properties of the original concrete," etc.; yet he does not state the nature of this dependence or how it is brought out by his tests, nor does he give the reader any clue to the "character" of the concrete used. It seems probable that the aggregate was graded to a maximum size of $\frac{1}{2}$ to $\frac{3}{4}$ in., since 3 by 6-in. cylinders were tested. If this is true, the mixtures of 1 part sand to 2 parts coarse aggregate would give a poorly balanced aggregate with an excess of coarse particles.

It is stated that 1600 tests were made. Eighty points are found on the diagram. We can assume that either 20 tests were averaged for each point, or that other ages, curing conditions, etc., were included, but not mentioned in the report. If 20 tests were made, we would expect a greater regularity in the curves.

The disregard of the proper balance between water content and the quantity of hydrated lime is, as stated by Mr. Emley, the cause of the confusion which has resulted from many tests carried out by earlier investigators.

In discussing Examples 1 and 2, it is stated that "in both of the above examples the addition of 10 per cent of lime is apparently beneficial, but the effects are within the probable experimental error." It should be borne in mind that this refers to strength variations from 2100 to 2250 lb. per sq. in., and flows from 172 to 187, but in Example 3 we find that the percentage of mixing water is recorded to the nearest 0.1 per cent. A variation of 0.1 per cent in mixing water is shown by Mr. Emley's tests for this mixture to make a difference of 30 to 75 lb. per sq. in. in the strength of the concrete; yet we find the strength worked out to the nearest *single pound*. Without a proper weighting of values, tests may seem to indicate something quite different from what the data really show. In our test reports concrete strengths are recorded to the nearest 10 lb. per sq. in., although the values may be based on 10 to 30 independent tests.

Mr. Berry seems to be in considerable doubt as to what his tests do show, as one must conclude from the following statements which appear in a single paragraph of his discussion:

1. "Hence, it is not conclusively shown by an examination of the table whether the lime increased or decreased the strength of the concrete."

Mr. Abrams.

2. ". . . yet, since in six of the eight cases the strength is actually greater, we must conclude that the lime does not decrease the strength of the concrete but adds to it."

3. ". . . again tending to show that the addition of lime has no harmful effect on the strength of the concrete."

The following "conclusions" may also be drawn from these tests:

1. Concrete of wet consistency containing hydrated lime gave strengths equal to or greater than similar concrete of dry consistency. (Six out of eight instances show this relation, considering 2889 and 2842 equal.) This is contrary to the results obtained by all experienced concrete testers. It seems doubtful, however, whether the terms "wet" and "dry" properly designate these consistencies.

2. Crushed trap gave higher strength than gravel in the 1 : 2 : 4 mix, and the reverse in the 1 : 2½ : 5. These results are contradictory.

3. For the dry mixes, hydrated lime increased the strength of trap concrete, but decreased the strength of gravel concrete; for the wet mixes, lime increased the strength in all cases. This reversal should be explained.

The higher strengths generally found with hydrated lime in Mr. Berry's tests are due to the use of aggregate graded too coarse for the quantity of cement in the mix, *and to no other cause.* The fineness modulus of the mixed aggregate was 5.7 for the gravel and 6.1 for the crushed trap, whereas the maximum permissible values for ¾-in. aggregate in the mixtures used by Mr. Berry are about 5.0[1] and 4.7 for gravel and crushed rock, respectively. Our tests showed that in "lean mixtures (1 : 9 to 1 : 6) and those with aggregates graded too coarse for the quantity of cement used, the strength was little affected or was slightly increased by admixtures up to 50 per cent," (20 per cent by weight, for hydrated lime). (Compare our Table VI, and Conclusion 6, *Proceedings*, Vol. XX, Part II, p. 201). Hydrated lime acts exactly like a fine aggregate in improving the grading of an aggregate which is too coarse and hence produces an entirely different effect from that found in *normal* concrete mixtures in which the aggregate is properly graded for the quantity of cement used.

Judging by the results of many thousand tests carried out in this laboratory, it appears that a variation of about 20 per cent in either direction must be allowed in Mr. Berry's average values to enable the strengths given to conform to relations which are well established. Reporting strengths to the *nearest pound* gives a false impression of the

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[1] See "Design of Concrete Mixtures," by Duff A. Abrams, *Bulletin 1*, Table 3, Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill.

Mr. Abrams. accuracy of the tests, when single values may be in error 400 or 500 lb. per sq. in. Our tests showed that parallel averages each based on 10 independent tests may vary as much as 5 per cent from the mean. It seems probable that the strength values for 1 : 2 : 4 gravel concrete using 5 and 10 per cent of lime are duplicated for dry and wet concrete due to some error.

Considerable experience and the greatest care are necessary in carrying out each detail of the tests in order to secure results of value; this is especially true when we attempt to establish underlying principles. A wide range of mixtures, consistencies, gradings of aggregate and percentages of lime must be used in establishing the effect of hydrated lime in concrete.

Tests which contain numerous obvious contradictions cannot be accepted as establishing other fundamental relations. The wide variation in Mr. Berry's tests and the contradictory results noted above are no doubt due in part to the improper grading of aggregates.

Mr. Shertzer. MR. T. B. SHERTZER (*Closure by letter*).—In Mr. Abrams' discussion of my paper (Appendix I), the method of determining "normal consistency" for hydrated lime paste by means of the Vicat needle is defended. I can only repeat that this method is not reliable for hydrated lime and that it is impossible to obtain consistent results with hydrated lime by following the method specified for portland cement.

The sub-division of the term "absorbtive" into four headings is not original with me; it is the accepted conception of the term among those familiar with the properties of lime. It is unfortunate that only a part of the paragraph was quoted in the discussion, the complete paragraph conveys an entirely different meaning than does the partial quotation. My statement that "Hydrated lime has the property of absorbing its own weight, or more, of water" is true when speaking of hydrated lime in general. Whether or not it applies to any individual hydrated lime is beside the point. This, and other properties of individual hydrated limes, varies as do the individual characteristics of any natural product. The water to "compensate" for the hydrated lime appears to have been proportioned on the assumption that pastes of portland cement and hydrated lime of so-called "normal consistency" can be mixed and will produce a resulting paste of "normal consistency." This is not the case; the mixed paste will be wetter than "normal consistency."

The statement to the effect that the amount of water *by volume* required to produce pastes of normal consistency for the 18 powdered admixtures is practically constant is not borne out by the data sub-

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mitted in his Table III (*Proceedings*, Vol. XX, Part II, p. 155). If we reduce the *weight* percentages of water, as of series 130, to the equivalent *volume* percentages they vary from 24 to 56 per cent. This is hardly ". . . practically constant for the 18 powdered admixtures. . . ." In my analysis I was very careful to point out that "In the case of lime it must first *dry out*, or *desiccate*, and when the proper conditions as to moisture content are reached, it absorbs carbon dioxide from the air and is changed into crystallin calcium carbonate." Mr. Abrams' characterization of a partial quotation as "beside the point" is a poor argument. The distortion and misrepresentation of my statement and the accompanying argument is a confession that it was impossible for the hydrated lime to show its true worth in 28-day old specimens kept wet for the entire period. In practical construction, the concrete and admixed hydrated lime has a chance to dry out and to develop the real value of the hydrated lime.

I do object to the method of determining the water content of the other "relative consistencies" (with hydrated lime) by *multiplying* the *total* water content of the concretes of normal consistency (with hydrated lime) by arbitrary factors. It is obvious that it is intended to convey the impression that the tests were conducted in such a manner as to show the effects of hydrated lime admixtures on *concretes* of a graduated series of consistencies. We are in full accord with this idea but the tests as conducted did no such thing. Concretes without hydrated lime were compared with concretes of a wetter consistency with hydrated lime.

On page 4 of *Bulletin 1* of the Lewis Institute, Mr. Abrams states: "The strength of the concrete responds to changes in water regardless of the reason for these changes." Early in my analysis it was pointed out that any water over and above that which could be restrained by the lime was free water. It is fair to assume that when a paste of normal consistency is made, the material of which the paste is made is *restraining* its maximum amount of water, If more water is added, when the material is used as an admixture, it is evident that it will only make the *concrete* wetter and not the admixed material.

A very weak argument is advanced to refute my statements in connection with my Tables II and III. Mr. Abrams says: "His confusion arises from the fact that we recorded the total quantity of mixing water added to the batch, without correction for absorbtion of water by the aggregate. It is obvious that it is proper to make such a correction." It is also obvious that had a correction been made the discrepancy noted would have been *greater* than indicated in my tables.

Mr. Shertzer. On page 20 of *Bulletin 1* of the Lewis Institute, Mr. Abrams stated: "However, it is only the water which goes to the cement (that is, exclusive of absorbed water) which affects the concrete strength. The failure to recognize this fact has led to many erroneous conclusions from tests made to determine the relative merits of different aggregates."

It is of passing interest to note that I have reduced every table published by Mr. Abrams which I have been able to find similar to his Table IV in the same way that I reduced the data for Table IV of my analysis. In no other case have I found any variation.

The following statements do not appear to be consistent:

> "Except for the wetter mixtures, the total discrepancy to which he calls attention represents a variation of not more than 2 per cent, which would not appreciably affect the strength" (Discussion).
>
> "In other words, increasing the mixing water 13 per cent causes the same reduction in strength as if we should omit 33 per cent of the cement" (Page 18, *Bulletin 1*, Lewis Institute).
>
> "One pint more water than necessary to produce a plastic concrete reduces the strength to the same extent as if we should omit 2 to 3 lb. of cement from a 1-bag batch." (Page 18, *Bulletin 1*, Lewis Institute.)

It is unfortunate that no figures are given for the water ratios used in the second section of Table III (*Proceedings*, Vol. 21, p. 308). Referring to Fig. 5 (*Proceedings*, Vol. 21, p. 312) and scaling the water increments for the several percentages of hydrated lime admixtures, it will be found that there was approximately 33 per cent less water used to "compensate for the lime" on the "constant flow" basis than on the "computation" basis in the mix of relative consistency 1.10. This difference becomes greater as the mixes become wetter because of multiplication. If the corresponding strengths, from Tables I and III (*Proceedings*, Vol. 21, pp. 305 and 308), be compared, it will be found that the strengths of all specimens containing hydrated lime averaged 89.1 per cent of the strength of the plain specimens for Group 1 and 94.2 per cent for Group 4. In other words, apportioning the water by the "constant flow" method reduced the *apparent* strength reduction by about one-half, or from −10.9 per cent to −5.8 per cent. In Table V (*Proceedings*, Vol 21, p. 313), Mr. Abrams acknowledges a variation of 2.43 per cent between the averages of duplicate sets of 10 specimens of the *plain* concrete for the same groups, thus reducing the *probable* average reduction chargeable to the hydrated lime and the water allowed for it to 3.37 per cent. This is certainly nothing to justify his conclusions. It does, on the other hand, substantiate my contention that the amount of

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water to compensate for the lime should have been proportioned on the basis of workability and not by arbitrary and emperical methods.

In discussing my Fig. 2, it is rather difficult to reconcile his argument with the statements on pages 168 and 172 of *Proceedings*, Vol. XX, Part II: "Many previous investigations have shown that there is a fixed relation between the water ratio and the strength of concrete, *regardless of the reason for the use of a particular quantity of water*, so long as the concrete is plastic and the aggregate is not too coarse for the quantity of cement used. . . . In computing the water ratio, *all water except that absorbed by the aggregate was accredited to the cement:* that is, the water absorbed by the hydrated lime was not deducted. *These curves show that the water ratio - strength relation holds with and without hydrated lime*, although the relation is not the same. *It was found impracticable to determine the absorption of hydrated lime*, although it is probable that if correction could be made for this factor, the water ratio - strength relation would be found to hold for concrete containing admixtures in the same manner as has been found for those without admixtures." All italics in the above quotation are mine.

On page 13 of *Bulletin 1* of the Lewis Institute, in describing his water proportioning formula it is stated: "In case admixtures of any kind are used, another term must be inserted in the equation. This relation has been fully worked out, but is not included in this report." Bearing in mind that he has frequently stated that the strength varies with the water-cement ratio regardless of the reason for water changes, that he added water to compensate for the hydrated lime, that he multiplied this water allowance for the wetter consistencies, that he confesses that he *made no allowances for the water absorbed by the aggregate* or hydrated lime but accredited it all to the cement, that he states in his discussion: ". . . since the lime must combine in a mixture which is plastic in the same way as the cement," and "However, in the case of concrete with an excess of mixing water, the cement particles are so dispersed and the resulting solution is so diluted that it is greatly weakened as compared with a concrete mixed to normal consistency," it is rather difficult to see the force of his latest argument. His charge that I juggled figures appears to be in rather poor taste.

The discussion regarding effects of hydrated lime on concretes in which the mixing water is constant is entirely beside the point and evidently was introduced to cloud the issue.

The insinuation intended to be conveyed by stating that: "Mr. Shertzer has based his comparisons on a 'general average value',"

Mr. Shertzer. loses its force when the methods used in the tests are taken into account. Throughout, nothing but average values are reported; these *average* values are plotted and all beneficial effects ingored by drawing in smooth curves by eye, and the conclusions drawn from the average slopes of the curves (see Tables XVIII and XIX, *Proceedings*, Vol. XX, Part II, pp. 188 and 189), for the 1 : 5 and richer mixes only, but for all percentages of hydrated lime and for all relative consistencies (Table XVIII).

In connection with my Fig. 4, it will be noted that with the exception of three points in concrete too dry for practical use, a decided improvement in both strength and flow is caused by all percentages of hydrated lime in the 1 : 6 mix. Plotting the 1 : 5 mix in the same manner shows that 5 per cent of lime has markedly beneficial effects all the way through, that 10 per cent is beneficial within the range of practical flow (180–210) and that the maximum decrease in strength shown by 20 per cent is about 11 per cent at flow 230, at flow 180 the decrease is but about 2 per cent while at 195 there is an increase of about 3 per cent.

Hydrated lime is seldom advocated in a mix as rich as 1 : 4. Its use is justified only by special conditions. The usual maximum amount used is about 10 per cent by volume of cement. Within the usual working range (flow 180–230) the *maximum* decrease in strength for 10 per cent as shown by plotting the data is about 9 per cent and this at flow 230. The reduction for 10 per cent at flow 180 is but $1\frac{1}{2}$ per cent.

It is again difficult to reconcile the criticism of my Fig. 5 with the statement to be found on page 3 of *Bulletin 1* of the Lewis Institute: "It is seen at once that the size and grading of the aggregate and the quantity of cement are no longer of any importance except in so far as these factors influence the quantity of water required to produce a workable mix." My graphs were only an adaptation of Mr. Abrams' own water-cement ratio theory.

Mr. Abrams evidently failed to read carefully the paragraphs immediately preceding and following my presentation of the summary of the mathematical analysis. He appears to have missed the point that I arrived at the values presented by applying his own published water-ratio and strength formulas to the data presented.

From Mr. Abrams' own statements we have it that he *did* allow for water absorbed by the aggregates and that he *did not*, that he has fully worked out the influence of any admixture on the water ratio and that he has found it impracticable to determine the absorbtion of hydrated lime; that when water is added to concrete it is

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weakened by the dispersion of the cement particles but when the same thing is done on account of hydrated lime admixtures it is the lime which causes the weakening; that "the strength of concrete responds to changes in water regardless of the reasons for these changes" excepting when water is multiplied on account of hydrated lime when the hydrated lime causes the reduction in strength. Several similar inconsistencies can be pointed out. After a careful review of all of the papers and data involved the impartial reader will, I am sure, agree that the data presented do not substantiate the conclusions.

REPORT OF COMMITTEE C-8

ON

REFRACTORIES.

Committee C-8 has held three general meetings during the year.

The committee does not have any changes to recommend at this time in the existing standards under its jurisdiction nor any tentative standards to submit.

The committee during the past year has formed two new sub-committees, one devoted to the study of magnesite refractories which will include methods of testing, and one to take up the subject of glass house refractories. Refractories will constitute a very important line of work as the problems to be met are very complicated and will require a considerable amount of investigative work.

During the past year, Sub-Committee II on Analysis has done considerable work on the study of methods suitable for the analysis of magnesite materials. Since these materials may vary widely in their physical characteristics, the development of a single method has not been easy. It is not ready as yet to report on tentative methods but hopes that it will be in a position to do so by next year.

Sub-Committee IV on Thermal Conductivity and Expansion has been studying the fundamental considerations involving the transfer of heat through refractory materials and presents as Appendix I to this report a summary of its work.

In accordance with the suggestions of Committee E-1, Committee C-8 appointed a Sub-Committee on Precision and Tolerances. This sub-committee has been working very diligently on this problem for the past year and their preliminary report is presented in Appendix II to this report. This preliminary report is published in the hope that the committee may be favored by criticism of the method they have adopted in attacking this problem.

This report has been submitted to letter ballot of the committee, which consists of 46 members, of whom 38 have voted affirmatively, 1 negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

R. C. PURDY,
Chairman.

W. H. FULWEILER,
Secretary.

APPENDIX I.

THE STATUS OF THERMAL CONDUCTIVITY IN SPECIFICATIONS FOR REFRACTORIES.[1]

By W. A. Hull.[2]

In connection with the work of Committee C-8 on Refractories, and particularly with that of the Sub-Committee on Thermal Conductivity, it seems worth while to consider, briefly, the relation of thermal conductivity to other properties of refractories and to attempt to find what place, if any, this property will have in specifications for refractories. It may also be worth while to try to determine what is most needed in the way of data and of methods of test.

In practically all the uses to which refractories are put, the most essential requirement is that they shall resist destructive agencies, including heat, erosion, the chemical action of the constituents of furnace gases and the corrosive action of slags and glasses. No single type of material will resist all the destructive agencies successfully; neither are all the destructive agencies found in any one furnace. The primary purpose of a specification is to state, quantitatively, the properties which a refractory material must have in order to resist, for a reasonable length of time, the destructive agencies which will be encountered in a specific place in a particular type of furnace. In general, only one type of refractory material is suitable for a given purpose. Most of the high temperature furnace work calls for high grade fire-clay brick; for certain conditions, silica refractories are practically always used, and other conditions call for other types. It has been sufficiently well established that the difference in thermal conductivity between different brands, or grades of brick within a given type or class are not important as compared with differences in refractoriness, in resistance to spalling, resistance to slag corrosion, etc. It seems probable, therefore, that in the great majority of cases, these properties which are essential to resistance to destructive agencies and which vary to an important extent from one brand of brick to another will be made the matters of specification regardless of the thermal conductivity. There are cases, however, in which the selection of the *type* of refractory to be used for a given purpose is influenced by the relative conductivities of different types and in cases of this sort, where more than one type is available and the conductivity is especially important, heat conductivity may eventually become a matter of specification.

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[1] By permission of the Director, Bureau of Standards.

[2] Physicist, U. S. Bureau of Standards.

Since thermal conductivity may be a factor in the selection of the type of brick to be used for a given purpose, it is important to have reliable data as to the conductivity of the different refractory materials, and it may be worth while to consider the completeness and the reliability of the figures now available.

Unfortunately, the figures given in many of the tables to be found in handbooks and elsewhere have been taken from unsatisfactory sources and are somewhat confusing. This applies particularly to the data obtained from the investigation by Wologdine[1] which were for a number of years (1909–1915) the best data available on the heat conductivity of refractory materials and have, in consequence, been very extensively quoted.

Wologdine made a very comprehensive investigation of the heat conductivity, porosity and gas permeability of a large number of refractory materials. The fact that he was given a research scholarship for this investigation by La Société d'Encouragement pour l'Industrie Nationale and that the work was done in the laboratories of Professor Le Chatelier and under his general supervision gives the results a strong claim on reliability. On the other hand, a study of the method of investigation adopted by Wologdine and particularly of the nature of the test specimens used, indicates that a certain amount of discrimination would have to be exercised in the use of his results. His method required the use of specially prepared test specimens instead of bricks made in the regular way and burned in commercial kilns. Instead of having the test specimens of each material burned to maturity, he burned most of them to one of two temperatures, some specimens to 1050° C. and the others to 1300° C. Of course, none of the specimens of refractory materials that were burned to 1050° C. had the properties of any commercial product whatever. The same may be said of at least a part of the specimens that were burned to 1300° C., especially those from bauxite, silica and magnesia. It is difficult, in going over Wologdine's results, to find record of a single group of specimens that appears to have been burned to the temperature to which the material would have been burned commercially; it appears to have been the purpose of the investigator to show the effect of the temperature of burning on the conductivity of the various materials rather than to provide data for the use of engineers and others who might have occasion to estimate heat losses in connection with the design of furnace installations. It is entirely probable that this has resulted in the conclusion, on the part of many engineers who have wished to make a quick calculation without taking the time to make a thorough study of the subject, that the figures for thermal conductivity were so inconsistent as to be valueless.

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[1] *Bulletin*, Soc. d'Encour., p. 879 (1909); *Journal*, Soc. Chem. Ind. (1909).

In 1915, important work on thermal conductivity of refractories was reported by one American[1] and a group of British[2] investigators.

The work of Dudley has much to recommend it. His determinations were made on large specimens built up from several full-size bricks and he used well-known American brands of fire brick, thereby establishing the identity of the materials on which his conductivity determinations were made. His description of his method indicates that his work was done with what may be termed good engineering accuracy.

The work done by Dougill, Hodsman and Cobb appears to have been well planned and skilfully executed. Their method permitted the use of commercial bricks, made and burned in the regular way. While their determinations were not made on the same brands of brick as Dudley's, they included approximately the same classes of refractories that he tested and a comparison of those results which are comparable, from these two investigations, given in Table I, shows as close agreement as could be expected. While most of their results are expressed as the mean k for the specimen under the temperature conditions existing in it at the time the determination was made, both Dudley and Dougill, Hodsman and Cobb computed, from their data, the coefficients of thermal conductivity of some of the materials which they investigated, for different temperatures up to 1000° C. Dougill, Hodsman and Cobb deduced the following formulas:

For fire-clay brick, $k_t = 0.00155 + 0.25 \times 10^{-5} t$ . . . . (1)
For magnesia brick, $k_t = 0.0285 - 0.379 \times 10^{-4} t + 0.179 \times 10^{-7} / t^2$ . . . . . . (2)

in which k_t is the thermal conductivity at any specified temperature and t is the temperature.

According to Eq. 1, the conductivity of fire-clay brick would be 0.0020 at 200° C. and 0.0040 at 1000° C. Dudley's computations gave 0.0019 at 200° C. and 0.0034 at 1000° C. Dudley's figure is therefore approximately 5 per cent lower at 200° C. and 15 per cent lower at 1000° C. than those of the other investigators. There is not necessarily any inconsistency in these results as they are as close as should be expected from bricks of different characteristics, even within the same general class.

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[1] "The Thermal Conductivity of Refractories," by Boyd Dudley, Jr., *Transactions*, American Electrochemical Society. Vol. XXVII, p. 285 (1915).

[2] "The Thermal Conductivity of Refractory Materials," by G. Dougill, H. J. Hodsman and J. W. Cobb. ***Journal***, Soc. Chem. Ind., Vol. 34 (1915).

A study of the data of both investigations indicates, also, that while the values obtained for silica brick are somewhat higher than those for the more porous grades of fire-clay brick, they correspond closely with those to be derived from the above formula for fire-clay brick. For example, this formula gives, for 1000° C., a conductivity of 0.0040, whereas Dudley's figure for silica brick, at the same temperature, is 0.0043. Values for temperatures above 1000° C., obtained by extrapolation, would be sufficiently close for most purposes.

TABLE I.

Class of Refractory.	Investigator.	Brand or Make.	Temperature Range, deg. Cent.		Mean Thermal Conductivity.[1]	Remarks.
			Inner Surface.	Outer Surface.		
Fire-clay	A[2]	Woodland	965	120	0.0026	
		"	1025	100	0.0026	
		"	995	400	0.0027	
	B[3]	Farnley	825	260	0.0029	Hard fired—Seger cone 10–11, approximately.
		"	970	300	0.0029	
		"	1080	330	0.0036	
		"	1440	550	0.0040	
		"	1100	420	0.0033	
		"	1350	510	0.0039	Another specimen.
Silicious Brick with Clay Bond	A	Quartzite	935	100	0.0026	
		"	960	100	0.0026	
	B	Farnley	1300	310	0.0025	Many quartz grains.
Silica Brick	A	Star	910	100	0.0031	
	B	Gregory	995	295	0.0030	
		"	1210	370	0.0035	Coarse grained.
		"	1240	440	0.0039	
		"	1395	440	0.0042	
Magnesite Brick	A		830	445	0.0135	
	B	Mabor	875	525	0.0110	
		"	1040	590	0.0098	
		"	1370	600	0.0091	

[1] Calory per sec. per sq. cm. for a temperature gradient of 1° C. per cm.

[2] Dudley.

[3] Dougill, Hodsman and Cobb.

All things considered, it seems entirely reasonable to accept results of these investigations and to make use of the formulas of Dougill, Hodsman and Cobb in ordinary engineering computations, making allowance for the fact that the values will be lower in the case of porous, light-burned brick and higher with denser brick. It is true that only rough estimates can be obtained in this way but it must be taken into consideration that only rough estimates of the heat transfer through the walls of a given installation could be obtained by computation, in most cases, even though precise figures for the thermal conductivity of the fire brick were available. In the first place, the temperatures of the inner and outer surface must be known and if the wall is to be more than one brick thick, the effect of the joint, or joints, must also be known as well as the conductivity of the refractory material before the heat flow through the wall can be computed. Unless the temperatures of the two surfaces can actually be measured, a rough approximation is introduced at this point. The effect of joints must not be overlooked and introduces another factor that is uncertain as to magnitude.

Furthermore, it must be taken into consideration that heat conductivity, or its reciprocal, resistance to heat flow, is but one of several factors, working in series and that the larger the two factors, such as surface resistance and the effects of joints, the smaller, relatively, is the effect of differences or errors in the values assumed for thermal conductivity. The effect of surface resistance is shown in the operation of retorts, in a gas plant, by the fact that when the flame changes from transparent to luminous the rate of production of gas increases, showing that heat is passing into the retorts more rapidly. When the flame is transparent, a very large portion of the heat must be taken up by the retort by conduction; when the flame becomes luminous, radiant energy is transferred rapidly from the myriad of minute particles of incandescent carbon floating in the gas to the surface of the retort, and the retort is heated by radiation, eliminating, to a large extent, the effect of the surface resistance at the outer surface. The fact that the difference in rate of production is considerable shows that the surface resistance is a large factor. This factor has been studied sufficiently to justify the statement that the surface resistance of one surface of a retort may be as great as the internal resistance of the wall itself.

There is one other factor that should not be lost sight of in this connection. In the case of furnaces operating at high temperatures, there is a tendency for a portion of the brick to vitrify, in course of time, increasing the conductivity of that portion by possibly 40 to 50 per cent. Also, under certain conditions, refractories become impregnated with various substances taken up from the gases penetrating them and it is practically certain that the impregnated materials differ to an important extent in heat conductivity and in other properties, from the original material.

It is not the purpose of the foregoing discussion to discourage the making of computations, but it is thought that some computers may believe, erroneously, that the lack of reliable figures for thermal conductivity is the greatest obstacle in the way of obtaining reliable estimates of the heat transfer to be expected in a given case, whereas, as a matter of fact, the more one studies the problem, the less concern is felt about the accuracy of the value ascribed to the conductivity of the material in question; other factors which necessarily enter into the computation have to be approximated so roughly that the uncertainty involved in this one becomes relatively unimportant.

The fact remains, however, that in certain places, particularly in muffles and retorts, high conductivity is important because it is essential to efficiency, whereas in others, particularly in the insulating courses that are used in certain conditions, back of refractory linings, low conductivity is important for the same reason. With the advent of carborundum and other high conductivity refractories, as well as the introduction of new insulating materials, an increasing interest is being taken in the heat conductivity of refractories and it is important that a standard method for making conductivity determinations should be developed. Of eight or more investigations, of more or less merit, the description and results of which have been published within the last fifteen years, no two have followed the same method and none of the investigators, apparently, has continued the making of conductivity measurements after the initial work was completed. There are now few if any commercial laboratories to which refractory materials may be sent for the measurement of their heat conductivity. There is need for a standard method for this test in order that the results of tests made in different laboratories shall be comparable. The method should be simple so that routine tests can be made, with apparatus of moderate cost, with reasonable accuracy, by an operator of reasonable ability and experience. The routine determination of heat conductivity should be taken out of the class of highly scientific investigative work and made a matter of every day commercial laboratory testing. It would be a waste of time to make conductivity determinations with great precision on samples of fire brick because the properties of different samples, even of brick of the same brand, would vary somewhat. On the other hand, it is essential that any method adopted be capable of giving results that can be depended on for reasonable accuracy, say to about five per cent.

In answer to the question which naturally arises, in this connection, as to what the Bureau of Standards is prepared to contribute in the way of a suggested method, it may be said that the Bureau has been working, for a number of years, on the determination of thermal conductivity, the earlier work being done at low temperatures. Data obtained from this work are to be found in an article entitled "Thermal Conductivity of Heat Insulators" by M. S. VanDusen in the *Journal* of the American Society of Refrigerating Engineers, November, 1920, and the *Journal* of the Society of Heating and Ventilating Engineers, October, 1920. Work is now nearing completion on a method for the accurate determination of the conductivity of refractory materials. While this method will not be adapted to the making of approximate determinations, in a routine way, it is believed that the knowledge and experience that have been gained in connection with the more refined work that has been done will make it possible to develop a test method which will be suitable for such use.

The situation in regard to heat conductivity may be summed up as follows: Differences in thermal conductivity between different brands or kinds of refractory materials within a given class, such as high grade fire-clay refractories, while they may be considerable, are comparatively unimportant so far as the efficiency of an installation is concerned, because the conductivity of the material constituting a wall is only one of several factors working in series, to affect rate of heat transmission. Thus, a 10-per-cent difference in conductivity may make only a 5 or a 2-per-cent difference in the heat flow through a wall. On the other hand, the difference in conductivity between two types of materials such as fire-clay refractories and carborundum refractories may be relatively important for such purposes as the walls of retorts and muffles. It is not unreasonable to expect that conductivity will become a matter of specification for refractory materials for certain purposes.

In regard to the question of obtaining satisfactory figures for use in computing heat flow through walls of various types in furnaces, attention is called to the fact that while the data of Wologdine, which have been copied extensively in physical tables, are likely to be misleading unless his work is discriminatingly studied, the data of Dudley and of Dougill, Hodsman and Cobb appear to be satisfactory for ordinary purposes. These investigators made determinations on well-known commercial materials and their results check as closely as should be expected, considering the fact that the materials studied were not identical. The data from these investigations should be satisfactory to the engineer, considering the fact that he must accept rough approximations for other factors involved in computations of heat transfer through walls.

The different investigators who have made heat conductivity measurements have developed a variety of methods, all of which are elaborate and laborious. There is a need for a standard method for making routine conductivity tests of commercial materials. It is not essential that it should be a precision method but it is important that it be simple and reasonably convenient and at the same time accurate, within reasonable limits.

APPENDIX II.

REPORT OF SUB-COMMITTEE XI ON PRECISION AND TOLERANCES.

The Sub-Committee on Precision and Tolerances was created for the following purposes:

1. To study specifications formulated in the past by Committee C-8:
    - (*a*) Determination of the precision of which the prescribed methods are capable;
    - (*b*) Possible modifications which may bring about a higher degree of precision, in the event that the prescribed methods are found not to meet the requirements of engineering accuracy;
    - (*c*) Proper methods of sampling; number of samples desirable for given tests; rejection of measurements which may be considered "huge errors";
2. To consult the other sub-committees, so that precision studies of all proposed tests may be made before reports of the various sub-committees are submitted to the general committee.

PRELIMINARY STATEMENT.

The degree of accuracy with which laboratory results may be obtained is seldom realized even by those who make the tests. Moreover, the practical limitations of these tests are not fully appreciated except by those who use them constantly in connection with their application to industrial problems. These facts often lead to misinterpretation and misapplication of results, and cause laboratory tests to be regarded with distrust by practical men.

This sub-committee, therefore, recommends that a brief statement accompany each specification hereafter submitted by Committee C-8 for the guidance of those who use these specifications, but who do not have the opportunity of making a thorough study of their unavoidable limitations. This statement should contain an analysis of the accuracy with which results can be obtained, and a brief outline of errors to be avoided in application and interpretation.

The following illustrations are given: If any specifications involve change in volume of brick on reheating, precision of measurements cannot be ignored, as the results of this test are accurate to only about 10 per cent of the reported values. Another kind of limitation is shown by the load test, the results of which are often dependent solely upon the burn of the brick. A definite statement of these facts might well be embodied in the specifications.

PRECISION STUDY.

STANDARD METHOD OF TEST FOR REFRACTORY MATERIALS UNDER LOAD AT HIGH TEMPERATURES (C 16 - 20).[1]—Errors in the results may be brought about by—

(*a*) Inaccurate temperature control;
(*b*) Incorrect pressure;
(*c*) Eccentric loading;
(*d*) Errors in determining length of brick.

(*a*) With a properly calibrated thermocouple, temperatures can be controlled to within 10° C. in all parts of the furnace.

(*b*) An error of 0.6 to 0.9 per cent in the determination of the area of the brick is to be expected; this will lead to an error of 0.2 lb. per sq. in. in the computation of the load.

An additional error of 0.2 lb. per sq. in. is to be expected when the total load on the end of the beam is weighed only to the nearest pound. The combined error may amount to 0.4 lb. per sq. in. or 1.6 per cent of the load intended to be applied. This is slight as compared with (*d*).

(*c*) Although the operator is warned in the Method of Test C 16 - 20 against the danger of eccentric loading, too much emphasis cannot be laid upon this particular point. An error of several hundred per cent due to eccentric loading has been observed.

(*d*) Even with the utmost precaution, a precision greater than 0.03 in. in determining the change of length cannot be expected. When the change in length is small this is an appreciable percentage.

"*Probable Error*".—Load tests are usually made on a single brick, instead of in duplicate or on a number from the same lot. For that reason very few check results are available to the committee. However, from the small number of check results obtainable, it has been estimated that the "probable error" of the result of a single load test is approximately 5 to 10 per cent of the reported deformation.

Other Factors.—In the interpretation of results secured in the load test, the influence of processes and conditions of manufacture cannot be ignored. Light, medium, and hard-burned brick from the same batch may compress 10 per cent, 5 per cent, and 2 per cent, respectively. A similar variation arises from differences in grind or in pressure of molding. Inasmuch as brick are often heated on the end only, or are not subjected to appreciable pressure, it is not surprising that certain brick which show considerable deformation in the load test are particularly well adapted to certain forms of service.

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[1] 1921 Book of A.S.T.M. Standards.

Whenever possible, the test specimen should consist of standard 9 by $4\frac{1}{2}$ by $2\frac{1}{2}$-in. brick. Brick made of the same clays and of the same burn, but of different shape, will show different amounts of compression under the same load of 25 lb. per sq. in. For example, a 9 in. "Soap" will compress more and a "large 9-in." less than a standard 9-in. straight.

STANDARD METHOD OF TEST FOR SOFTENING POINT OF FIRE-CLAY BRICK (C 24 – 20).[1]—By the methods prescribed, check determinations of $\frac{1}{2}$ cone (about 10° C.) are regularly obtained on samples taken from different parts of the same brick. The fact should be recognized, however, that a greater difference may exist between different brick of the same shipment, and that a softening point determination based upon a single brick may give results slightly higher or slightly lower than the shipment it is intended to represent. The sub-committee recommends that softening point determinations should be made on a sample taken from six specimens selected from different parts of the hack or car.

STANDARD METHOD OF TEST FOR POROSITY AND PERMANENT VOLUME CHANGES IN REFRACTORY MATERIALS (C 20 – 20).[1]—The sub-committee recommends that the Secretary of Committee C-8 request Professor Washburn and Mr. G. A. Bole to prepare written discussions of Method of Test C 20 – 20 covering the following points:

1. Using the method prescribed, what degree of concordance can be expected from successive determinations?
2. Does the method meet the requirement of engineering accuracy?
3. Can the tests be made more accurate without being rendered more laborious? If so, in what manner?

By the methods prescribed, the exterior volume of the test specimen can be determined to within 5 per cent; the *apparent specific gravity* to the nearest hundredth; the *true specific gravity* approximately within 0.02.

It is questionable whether the open pores are completely filled by the treatment prescribed of 4 hours immersion at 25° C. in kerosene, under a vacuum of 24 in. If they are filled, the *volume of the open pores* can be determined within 0.5 per cent by this method; and the *volume of the sealed pores* to approximately 0.8 cc. in the standard test specimen, which has a volume of about 128 cc. With a small volume of sealed pores the percentage error would be very large.

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[1] 1921 Book of A.S.T.M. Standards.

The volume shrinkage should theoretically be determined within approximately 0.25 cc. in a 128-cc. specimen.

STANDARD DEFINITIONS FOR CLAY REFRACTORIES. (C 27 – 20).[1]—Objection has been raised to the title "Standard Definitions" on the ground that Standard Definitions C 27 – 20 really cover specifications and not definitions.

Section 3 of the Standard Definitions C 27 – 20 states that "The test for linear contraction or expansion referred to in the following definitions shall be conducted in accordance with the Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (Serial Designation: C 20) of the American Society for Testing Materials." These directions need to be clarified, inasmuch as Method of Test C 20 – 20 does not prescribe a method of determining *linear* contraction and expansion. It may be inferred from the language of Section 3 that 2½ by 2½ by 1¼-in. specimens shall be cut from standard 9-in. brick and the volume change determined by the Method of Test C 20 – 20; and that the linear change shall then be computed from the volume change.

In nearly all commercial laboratories the linear change is determined directly by measurements upon standard 9-in. brick before and after reheating. The sub-committee believes that, as a matter of laboratory economy, this should be done. By this method, however, any single determination cannot be expected to have a higher precision than 10 to 12 per cent of the reported value.

The fact has been brought out that the reheating test as prescribed may discriminate against medium-burned hand-made brick and against machine-made brick, and may favor hard-burned brick manufactured from identical clays.

The sub-committee recommends that the Sub-Committee on Definitions of Committee C-8 be directed to make a further study of the three points mentioned.

MODULUS OF RUPTURE OF SILICA BRICK.—In order to avoid excessive variation due to eccentricity of loading the recommendations are made that:

1. No sample should be tested in which the 9 by 2½-in. faces are not approximately parallel.
2. Compensation knife edges, as described in the Standard Specifications for Building Brick (C 21 – 20)[1] should be used.

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[1] 1921 Book of A.S.T.M. Standards.

The precision of any single determination of the modulus of rupture is approximately 3 per cent. Hence, results should be reported to the nearest pound, as fractions of a pound have no significance.

Silica brick show such wide variations in strength that a mean modulus computed from a small number of specimens can be regarded as merely approximate. The recommendation is made that the mean modulus be computed from:

1. Five specimens when accuracy is not desired;
2. Fifteen specimens for more accurate results. With this number the "Probable Error of the Mean" should be about 3 per cent.

Rejection of Observations.—With five determinations, reject any one where the deviation of the single observation from the mean exceeds 2.2 times the average deviation from the mean of the series.

With fifteen determinations, reject any one where the deviation of the single observation from the mean exceeds 2.7 times the average deviation from the mean of the series.

MEASUREMENTS OF DIMENSIONS OF BRICK.—From a series of measurements made upon standard 9 by $4\frac{1}{2}$ by $2\frac{1}{2}$-in. brick by skilled laboratory workers using calipers and steel scale and measuring to 0.01 in., it developed that the "probable error" of a single determination of length was 0.2 per cent, breadth 0.4 per cent, and thickness 1.2 per cent.

REPORT OF COMMITTEE C-9
ON
CONCRETE AND CONCRETE AGGREGATES.

The last annual report of the committee included a brief resumé of the work accomplished from the date of its inception and included also a statement of the work then under way.

During the past year there have been three meetings of the committee, one of which was devoted entirely to the discussion of the Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete[1] and the others to the regular work of the committee. There are attached to this report two appendices, one including the report of Committee C-9 on the Joint Committee report with a letter of transmittal which explains the attitude of Committee C-9 in reviewing this report. In the second appendix there are presented results of tests instituted with the idea of getting more definite information on the relative precision of the several methods advocated for design of concrete mixtures. These test results were submitted by the University of Texas, the Philadelphia Municipal Laboratory, the University of Toronto, and the Hydro-Electric Power Commission of Ontario, and were digested and prepared in their present form at the Lewis Institute, Chicago. The results are presented at this time merely as information and it is anticipated that they will be analyzed during the coming year.

The work of some of the sub-committees is progressing slowly, and in order to impel it more rapidly, the sub-committee personnel has been changed to some extent.

The scope of Sub-Committee XI has been increased by changing its title from "Sub-Committee on Accelerators" to "Sub-Committee on Admixtures." This sub-committee has been active during the past year and reports from a number of cooperating laboratories have been received on tests of accelerators initiated by this committee. The majority of these tests will have been completed during the coming year and a summary of the results, at least, will be presented in the next annual report.

Sub-Committee I on Definitions under Mr. L. R. Ferguson has done considerable work which should be apparent in a later report.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 212 (1921).

The results of Series 201 reported in Appendix II were obtained under the outline of tests made by Sub-Committees II and VI combined.

The chairman of Sub-Committee VI in cooperation with the representative of Committee D-4 on Road and Paving Materials has outlined the Tentative Method of Decantation Test for Sand and Other Fine Aggregates which is appended hereto[1] for acceptance as a tentative standard.

The committee recommends that the following tentative standards be advanced to standard:

- Method of Test for Voids in Fine Aggregate for Concrete (C 30 - 20 T).[2]
- Method of Test for Organic Impurities in Sands for Concrete (C 40 - 21 T).[3]
- Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 21 T).[4]

The result of a letter ballot of the committee upon the recommendations which have been made relative to the adoption of tentative standards as standards and the submission of additional tentative standards is given in the following table:

Items.	Affirmative.	Negative.	Not Voting.
I. PROPOSED NEW TENTATIVE STANDARDS.			
Tentative Method of Decantation Test for Sand and Other Fine Aggregates..........	33	1	6
II. TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD.			
Method of Test for Voids in Fine Aggregate for Concrete (C 30 - 20 T).............	32	1	7
Method of Test for Organic Impurities in Sands for Concrete (C 40 - 21 T)..........	34	0	6
Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 21 T)..........	31	2	7

This report has been submitted to letter ballot of the committee, which consists of 40 members, of whom 34 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. T. GOLDBECK,
Chairman.

J. C. PEARSON,
Secretary.

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[1] See p. 802.—ED.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 652 (1920).

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 585 (1921).

[4] *Ibid.*, p. 586.

EDITORIAL NOTE.

The Tentative Method of Test for Voids in Fine Aggregate for Concrete, the Tentative Method of Test for Organic Impurities in Sands for Concrete and the Tentative Method of Test for Sieve Analysis of Aggregates for Concrete were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1922.

The proposed Tentative Method of Decantation Test for Sand and Other Fine Aggregates was accepted for publication as tentative and appears on page 802.

APPENDIX I.

ON THE PROGRESS REPORT OF THE JOINT COMMITTEE ON STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE.

In order that the criticism of the Joint Committee's progress report on Specifications for Concrete and Reinforced Concrete submitted by Committee C-9 may be of permanent record, it has seemed advisable to append this criticism to the committee's annual report. In explanation of the committee's attitude toward the Joint Committee's recommendations, the transmitting letter to the Secretary of the Society is also reprinted herewith.

WASHINGTON, D. C., January 10, 1922.

MR. C. L. WARWICK, *Secretary-Treasurer*,
Philadelphia, Pa.

Dear Mr. Warwick:

In compliance with your request of September 13, 1921, I am transmitting herewith the report of Committee C-9 on the progress report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete which, as indicated therein, has been approved by a majority of the members of Committee C-9.

A number of our members have taken exception to some of the revisions or recommendations approved by the committee as a whole and have submitted their comments in writing. Believing that the Joint Committee is desirous of receiving the benefit of all possible constructive criticism, I am enclosing these comments as supplementary to our report and I would suggest that they be forwarded to the Joint Committee for their consideration.

In submitting our report I am very anxious to make clear to you the general attitude of the committee while reviewing the Joint Committee report. We had in mind that the Joint Committee wished to receive the comments of those who should be capable of advising them in order that they might be guided in their future deliberations. In view of the length of the report and of the short time at our command, we endeavored to devote our criticisms to those points which seemed most vital, and many details could therefore be given very little consideration.

I am now of the opinion that the sentence "It should be understood that where no changes are suggested the original text stands approved," appearing in the second paragraph of the comments, does not convey the correct impression. It will be understood that many of the paragraphs in the Joint Committee report had to be passed over by our committee in order that attention might be given to the more important points, and many paragraphs to which no reference is made in our report were neither approved nor disapproved. No doubt if Committee C-9 could have taken the time to consider the report in considerable detail other changes might have been suggested.

I should like also to call your attention to the fact that the recommended changes in the Aggregate Specifications have been made without reference to or comparison with the Society's Tentative Specifications for Concrete Aggregates (C 33 - 21 T) proposed by Committee C-9 at the last annual meeting. This has been done for the principal reason that our own standards are still in a formative stage and it is very probable that considerable change will be made before they are submitted to the Society for adoption as standard. Then, too, the differences between the two specifications are for the most part insignificant.

In submitting our report on the Joint Committee report, Committee C-9 does not feel finally bound to the ideas expressed. The report is merely a collective expression of the committee, giving the best advice of which we were capable at the time the report was reviewed. Our ideas both with regard to specifications and definitions at the present time are in a state of flux and we shall feel perfectly free to submit standards or definitions in the future not in agreement with our present report.

We have in mind that no doubt the Joint Committee will welcome future criticism and for this reason we believe that it would be very desirable if a future opportunity could be given for review of the Joint Committee report at least prior to its final adoption.

Very truly yours,
(Signed) A. T. GOLDBECK,
Chairman.

REPORT OF COMMITTEE C-9 ON THE PROGRESS REPORT OF THE JOINT COMMITTEE ON STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE, TO THE EXECUTIVE COMMITTEE.

In compliance with the request of the Secretary of the Society under date of September 13, 1921, a meeting of Committee C-9 was called on November 1, 1921, to consider the Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. At this meeting 19 members of Committee C-9 were present. After some discussion it was agreed that the following portions of the report should be reviewed.

SUB-DIVISION II.—Definitions of the following terms:

Aggregate, Coarse Aggregate, Concrete, Consistency, Crusher-run Stone, Cyclopean Concrete, Engineer, Fine Aggregate, Gravel, Laitance, Mortar, Oilproofing, One-man Stone, Plain Concrete, Portland Cement, Rubble Aggregate, Rubble Concrete, Sand, Screen, Sieve, Slump, Standard Sand, Stone Screenings.

SUB-DIVISION III.—Quality of Concrete.

SUB-DIVISION IV.—Materials (except metal reinforcement).

SUB-DIVISION V.—Proportioning and Mixing Concrete.

SUB-DIVISION IX.—Waterproofing and Protective Treatment, Section 83 on Concrete in Sea Water.

TABLE IV.—Proportions for Given Compressive Strength of Concrete at 28 Days.

The committee considered the above portions of the report and now recommends the following revisions. It should be understood that where no changes are suggested the original text stands approved.

II. DEFINITIONS.

Aggregate.—Change the definition to read:

"Inert material which is mixed with portland cement and water to produce concrete; in general aggregate consists of sand, gravel, crushed stone, crushed gravel, crushed slag, or similar materials." (The word "pebbles" is omitted as superfluous, and "crushed slag" is inserted as one of the typical aggregates.)

Consistency.—(The definition of the term is not satisfactory, but pending the report of the Sub-Committee on Consistency of Committee E-1, no substitute is offered at this time.)

Stone Screenings.—(The committee raises the question whether there is not an inconsistency between the definition and the specifications for fine aggregate, in view of the fact that stone screenings as defined could probably never pass the specifications. Stone screenings, however, from which the dust has been removed, known as "dustless stone screenings" *could* pass the specifications.)

Slag.—Air-cooled, blast furnace slag. (It is recommended that this definition be included in the list.)

III. QUALITY OF CONCRETE.

Section 3.—Change this paragraph to read as follows:

"The quality of the concrete shall be measured by its workability as determined by the slump test or other accepted tests for workability and by its compressive strength at 28 days as determined by concrete tests of the materials to be used. The proportions required to produce concrete having the strength specified in Section 4 shall be determined in advance of the mixing of the concrete." (The essential change in Section 3 is the substitution of "measured by" for "expressed in terms of", the former seeming better to express the intent of this section. It is believed that workability should not be limited to the slump test, since there are other methods equally as suitable.)

Section 4.—Change the first sentence to read:

"The proportions and workability of the concrete either specified by the engineer, or permitted by him, shall be such as to produce concrete of the following strength for the various parts of the work." (Section 4, as written, seems to be applicable only to the conditions specified in the second paragraph of Section 28, but not to the first; since, if the engineer specifies the proportions to be used, he cannot also specify the strength. The revision seems to provide for all contingencies in the sections numbered 28.)

IV. MATERIALS.

Section 8.—Change the percentage passing the No. 4 sieve from 95 to 85. (The committee feels that a somewhat larger percentage may be retained on the No. 4 sieve without injuring the quality of the aggregate, and since the general commercial use of the ¼-in. screen tends to produce a somewhat larger percentage of the coarsest particles, a larger tolerance on the No. 4 sieve is recommended.)

Section 11.—Add the following footnote with reference to the word "weight" in line 3:

"When approved by the engineer these proportions may be by volume, assuming one cubic foot of cement to weigh 94 lb." (The committee feels that in view of the wide variation in the weight of equal volumes of different fine aggregates, and in view of the general practice of proportioning concrete by volume, the volume method of proportioning should be permitted in mortar tests.)

Section 12.—Insert after "unless" in the fifth line the following:

"it complies with the requirements of Section 11, or". (This insertion emphasizes the fact that the Colorimetric Test serves only as a warning, and is not to be considered a basis for rejection when either mortar or concrete strength tests are satisfactory.)

Section 13.—Insert "slag" after "gravel". (It is believed that slag is entitled to recognition as a typical coarse aggregate.)

Section 14.—Change the upper limit clause to read as follows:

"Passing — in. sieve (maximum size) . . . not less than 95 per cent." (The text as printed reads, "Not more than 95 per cent," which appears to be an error.)

In the table accompanying this paragraph, footnote (*a*), it is recommended that in all places where 100 per cent appears this figure be changed to 95 per cent. (This is to make the table consistent with the text of Section 14.)

It is also recommended that this table include the ½-in. maximum size of aggregate. (This is in recognition of the fact that such aggregate is frequently used.)

Section 15.—Add the serial designation "C 41 - 21 T" following "Tentative Method of Test for Sieve Analysis of Aggregates for Concrete."

V. PROPORTIONING AND MIXING CONCRETE.

Section 27.—For "an automatic device" in the sixth line, substitute "means". (There seems to be no justification for requiring an *automatic* water measuring device.)

Section 28.—Omit the first sentence. (This is considered unnecessary and superfluous.) Change the second sentence, which now becomes the first sentence, to read:

"The proportioning shall be 1 part of portland cement, — parts of fine aggregate, and — parts of coarse aggregate, as determined by the engineer from concrete tests of the materials to be used, or by the use of Table IV." The remainder of the paragraph stands without change. (The insertion of the words "or by the use of Table IV" was deemed by the committee to be the best substitute for the method of proportioning given in the third section numbered 28. It was not believed desirable to include Table IV as a part of the specification but that it should be used as a guide in proportioning; consequently the elimination of the third section bearing the number 28 is recommended.)

In the second section numbered 28, for "frequent" in the third line, substitute "at regular periods". (This indicates somewhat more definitely that periodic control tests will be made.) At the end of the section add the following:

"The contractor shall be considered to have met the requirements of the specification when the average of all concrete tests made on each class of concrete is equal to or better than the requirements for that class. At least 75 per cent of the test specimens shall show a strength greater than 80 per cent of the specified requirement in any given class." (The committee favors the principle of giving the contractor an opportunity to furnish concrete of required strength according to his own methods, but the section as written allows him no latitude. Realizing the variable results which must be anticipated from tests of concrete made in the field, the committee has endeavored to recognize the rights of the contractor and to specify definitely what will be expected of him under this second method of proportioning.)

Eliminate the third section numbered 28. (See note following the first section 28 above.)

Section 29.—Substitute for this section the following:

"The engineer shall determine and specify the consistency of the concrete for various portions of the work. The consistency of the concrete shall be measured by the slump test or other approved tests for consistency. (See Tentative Specifications for Workability of Concrete for Concrete Pavements (D 62 – 20 T) of the American Society for Testing Materials. Appendix 12.) The slump for different types of concrete shall not be greater than indicated in Table II." (The foregoing eliminates superfluous expressions and provides more latitude in the determination of consistency.)

In the table accompanying Section 29, it is recommended that the slump for hand-finished roads and pavements be 2½ in. instead of 4 in. (A majority of the committee felt that the quality of road concrete should be maintained at the highest possible point and that a consistency indicated by a slump of 4 in. involved the use of an unnecessary amount of water.)

Section 31.—Change the time of mixing from 1½ minutes to 1 minute. (It is believed that sufficient test data are available on the effect of time of mixing to warrant this change.)

Section 32.—Substitute for this section the following:

"When hand mixing is authorized by the engineer it shall be done on a water-tight platform. The sand shall be spread on the platform and the cement spread evenly over the sand. The material shall then be shoveled into a cone shaped pile by casting centrally on the pile. This pile shall then be divided by casting into two or more cone shaped piles and the operation of dividing and reuniting continued until the batch is uniform in color. Only sufficient water to produce the desired consistency shall then be added by sprinkling as the batch is turned. The coarse aggregate previously moistened shall then be mixed with the mortar in the manner specified for mixing sand and cement." (The committee recommends this method of hand mixing as more definite and productive of better results.)

IX. WATERPROOFING AND PROTECTIVE TREATMENT.

Section 83.—Change the last sentence to read:

"Porous or weak aggregates shall not be used." (In view of the varying characteristics of some of the aggregates specifically mentioned it is believed unnecessary to exclude them as a class.)

This report has been submitted to letter ballot of the committee, which consists of 38 members, of whom .. have voted affirmatively, .. negatively, and .. have refrained from voting.

Respectfully submitted on behalf of the committee,

A. T. GOLDBECK,
Chairman.

J. C. PEARSON,
Secretary.

APPENDIX II.

SUMMARY OF DATA OBTAINED IN "SERIES 201", COMPRESSION TESTS OF CONCRETE MADE IN COOPERATION WITH COMMITTEE C-9.[1]

The data contained herein were summarized by D. A. Abrams from reports submitted by the following cooperating laboratories:

Department of Public Works, Philadelphia, Pa.
Submitted by F. B. Lysle, Assistant Engineer, Bureau of Surveys.

University of Texas, Austin, Texas.
Submitted by H. R. Thomas, Testing Engineer, Division of Engineering.

University of Toronto, Toronto, Canada.
Submitted by Peter Gillespie.

Hydro-Electric Power Commission of Ontario, Toronto, Canada.
Submitted by F. A. Gaby, Chief Engineer.

INTRODUCTION.

These reports cover compression tests of concrete which were outlined as "Series 201" by Sub-Committees II and VI of Committee C-9. The detailed outline of tests as approved by the committee formed a part of the report at the 1920 meeting of the Society. The outline gave details of methods to be followed in the selection and preparation of materials, proportioning, mixing, molding specimens, making tests, etc.[1]

According to the original outline this series "constitutes a study of the effect of size and grading of aggregate, and of variations in the quantities of cement and water on the strength and other properties of concrete."

DEFINITIONS OF TERMS.

The *fineness modulus* of an aggregate is the sum of the percentages in the sieve analyses, divided by 100, using the Tyler sieves 100, 48, 28, 14, 8, 4, $\frac{3}{8}$, $\frac{3}{4}$ and $1\frac{1}{2}$-in., and expressing the sieve analyses as total percentages coarser than each sieve. It is a function of the logarithm of the diameter of the particle.

The *surface area* of an aggregate is expressed as square inches per pound of aggregate; it is calculated on the assumption that the material of size 200–100 has a surface area of 13,700 sq. in. per lb., and that each coarser size group as determined by the sieves named above has a surface area one-half that of the next smaller group. The surface area of a given *volume* or *weight* of aggregate is inversely proportional to the average diameter of the particle.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 294 (1920).

The *surface modulus* of an aggregate is a function of the square of the diameter of the particle and is proportional to the surface area; it is computed on the basis that the surface modulus of the 200–100 size is 100 and that each coarser size group determined by the sieves named above has a surface modulus one-half the next smaller group.

TABLE I.—TESTS OF CEMENT.

(Department of Public Works, Philadelphia.)

All tests made in accordance with Standard Specifications and Tests for Portland Cement of the American Society for Testing Materials.

Cement.	Date Made.	Fineness Residue on			Normal Consistency, per cent by weight.	Time of Setting.				Tensile Strength of Briquettes, lb. per sq. in.		Soundness (over boiling water).
						Initial.		Final.				
		50	100	200		h.	m.	h.	m.	1 day.	7 days.	
A	Mar. 10, 1920	0.0	2.6	16.2	23.0	2	45	6	05	670	635	O.K.
	Oct. 27, 1920	0.0	2.8	14.0	22.0	2	01	6	11	390	620	O.K.
	Jan. 4, 1921	0.0	1.4	12.0	22.0	3	49	6	34	340	620	O.K.
	Average	0.0	2.3	14.1	22.0	2	52	6	17	470	625	
B	Mar. 10, 1920	0.0	1.6	11.6	23.0	3	25	5	55	410	650	O.K.
	Oct. 27, 1920	0.0	1.6	13.2	22.0	0	23	5	04	380	620	O.K.
	Jan. 4, 1921	0.0	3.0	22.0	22.0	3	34	5	39	250	550	O.K.
	Average	0.0	2.1	15.6	22.0	2	27	5	33	350	610	
C	Mar. 10, 1920	0.0	1.2	13.0	22.0	1	17	5	07	480	570	O.K.
	Oct. 27, 1920	0.0	0.8	9.0	22.0	1	37	5	27	410	630	O.K.
	Jan. 4, 1921	0.0	1.4	11.2	22.0	1	19	4	59	380	640	O.K.
	Average	0.0	1.1	11.1	22.0	1	24	5	11	420	610	

The *void-cement ratio* is the ratio of volume of water and air voids in concrete to the volume of dry cement, assuming 1 cu. ft. of cement to weigh 94 lb. The values given in the following tables were calculated from the density and yield of concrete.

REPORT OF TESTS MADE BY THE DEPARTMENT OF PUBLIC WORKS, PHILADELPHIA, PA.

This report covers tests in Group I, using seven gradings of sand and pebble aggregates, mixtures 1 : 7, 1 : 5, 1 : 3½ by volume, and six consistencies.

Concrete was hand-mixed, each batch forming one test piece. Specimens stored in a moist place and tested at 28 days. Six hundred and thirty 6 by 12-in. concrete cylinders were tested. The following is quoted from Mr. Lysle's report. "In these tests we merely made the determination of the normal consistencies of 1.0 and then calculated the varying amounts of water for the other consistencies."

TABLE II.—STRENGTH TESTS OF SAND MORTARS.

(Department of Public Works, Philadelphia.)

Portland cement donated by the Portland Cement Association.

Date Made.	Tension Tests of Briquettes, lb. per sq. in.								Compression Tests of 2 by 4-in. Cylinders, lb. per sq. in.							
	Mix 1 : 3 by Weight.				Mix 1 : 3 by Volume.				Mix 1 : 3 by Weight.				Mix 1 : 3 by Volume.			
	Standard Sand.		River Sand.		Standard Sand.		River Sand.		Standard Sand.		River Sand.		Standard Sand.		River Sand.	
	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.
CEMENT A.																
Mar. 10, 1920	380	485	320	440	305	440	275	370	2060	2410	1590	3140	1390	2620	1310	2210
Oct' 27, 1920	410	510	350	460	310	440	290	385	1850	2300	1800	2560	1220	2290	1300	2600
Jan. 4, 1921	335	485	290	410	275	425	240	355	1280	2420	1360	2920	970	1800	1160	2280
Average	375	490	320	440	300	435	270	370	1730	2380	1580	2870	1190	2240	1260	2360
CEMENT B.																
Mar. 10, 1920	310	435	270	410	260	375	230	340	1650	2540	1540	2310	1650	1850	1220	2150
Oct. 27, 1920	315	415	265	380	240	360	230	325	1350	2360	1290	2020	1220	1810	980	1680
Jan. 4, 1921	210	315	150	245	160	280	130	200	710	1350	600	1260	590	1250	480	1080
Average	280	390	230	340	220	340	200	290	1240	2080	1140	1860	1150	1640	890	1640
CEMENT C.																
Mar. 10, 1920	325	465	255	440	250	405	210	360	1420	2660	1230	2360	880	1630	830	2010
Oct. 27, 1920	285	445	235	370	220	350	190	300	980	1870	1000	1880	830	1530	730	1400
Jan. 4, 1921	345	465	270	395	255	400	220	345	1180	1840	1130	2140	840	1520	850	1500
Average	320	460	250	400	240	385	210	335	1190	2120	1120	2130	850	1560	800	1640
Grand Average	325	450	270	390	250	390	230	330	1390	2190	1280	2290	1060	1810	980	1880

TEST DATA.

The results of the tests are summarized in the attached tables. Table I gives standard tests of the three cements used in the concrete. Table II is a summary of strengths of sand mortars and Table III contains sieve analyses and other data

TABLE III.—TESTS OF AGGREGATE.

(Department of Public Works, Philadelphia.)

Sand and pebbles donated by the DeFrain Sand Co., Philadelphia.

Item.		Sand.	Gravel.	Mixed Concrete Aggregate					
				55.0[a]	31.6[a]	25.8[a]	20.0[a]	14.0[a]	8.2[a]
Sieve Analysis, amount coarser than each sieve, per cent by weight	Sieve No. 100	98	100	99	99	99	99	99	100
	Sieve No. 48[b]	87	100	93	96	97	98	98	99
	Sieve No. 28[b]	38	100	66	81	84	88	91	95
	Sieve No. 14[b]	21	100	57	75	80	85	89	93
	Sieve No. 8	12	100	51	72	77	82	88	93
	Sieve No. 4	2	100	46	69	75	80	86	92
	$\frac{3}{8}$-in	0	62	28	43	46	50	54	57
	$\frac{3}{4}$-in	..	23	10	15	17	18	20	21
	$1\frac{1}{2}$-in	...	0	0	0	0	0	0	0
Fineness modulus[1]		2.58	6.85	4.50	5.50	5.75	6.00	6.25	6.50
Surface area[1]		3090	140	1760	1070	900	730	550	380
Surface modulus[1]		22.6	1.0	12.8	7.8	6.6	5.3	4.0	2.7
Specific gravity		2.67	2.57	....	....	....	....	....	....
Absorption after 3-hr. immersion in water at room temperature		4.90	1.07	....	....	....	....	....	....
Unit weight, lb. per cu. ft.		107	106	123	126	124	123	118	113
Organic impurities		Just safe	....	....	....	....	....	....	....

[a] Sand, per cent by weight of total aggregate.

[b] Sieves No. 50, 30 and 16 have been substituted for No. 48, 28 and 14 in the Tentative Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 – 21 T).

[1] See text for explanation of these terms.

TABLE IV.—COMPRESSION TESTS OF CONCRETE.

(Department of Public Works, Philadelphia.)

Tests of 6 by 12-in. concrete cylinders.

Aggregate: sand and pebbles donated by the DeFrain Sand Co., Philadelphia.

Cement: a mixture of equal parts of three brands of portland cement donated by the Portland Cement Association.

Tests were made in accordance with "Outline of Compression Tests of Concrete for Investigation of Properties of Concrete Mixtures." See *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 294 (1920).

Specimens stored in a moist place until tested; tested damp at age of 28 days.

Each value is the average of 5 tests made on different days.

See text for explanation of Fineness Modulus, Surface Area and Surface Modulus.

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per sq. in.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
FINENESS MODULUS, 2.58; SURFACE AREA, 3090; SURFACE MODULUS, 22.6.									
1 : 7	54.5	0.80	1.80	....	116	1.18	0.60	3.31	210
		0.90	2.06	....	122	1.14	0.62	3.03	240
		1.00	2.30	0.75	122	1.15	0.62	3.06	220
		1.10	2.52	....	124	1.16	0.62	3.09	190
		1.25	2.86	....	126	1.19	0.596	3.37	140
		1.50	3.45	....	125	1.21	0.590	3.47	90
1 : 5	38.9	0.80	1.31	....	122	1.17	0.630	2.16	480
		0.90	1.46	....	126	1.14	0.643	2.04	440
		1.00	1.70	0.75	129	1.14	0.644	2.03	460
		1.10	1.89	....	129	1.16	0.634	2.12	370
		1.25	2.13	....	131	1.16	0.634	2.12	340
		1.50	2.56	....	133	1.19	0.620	2.26	200
1 : 3½	27.2	0.80	0.95	....	128	1.18	0.660	1.40	960
		0.90	1.07	....	132	1.16	0.668	1.35	1060
		1.00	1.19	0.87	132	1.17	0.668	1.36	1120
		1.10	1.31	....	132	1.19	0.654	1.44	970
		1.25	1.48	....	134	1.20	0.650	1.47	770
		1.50	1.78	....	134	1.23	0.629	1.60	520

[1] Square inches of aggregate per gram of cement.

[2] Volumes of concrete for one volume of aggregate.

TABLE IV.—COMPRESSION TESTS OF CONCRETE—(*Continued*).

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per sq. in.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in
FINENESS MODULUS, 4.50; SURFACE AREA, 1760; SURFACE MODULUS, 12.8.									
1 : 7	35.9	0.80	1.59	....	139	1.09	0.750	1.91	520
		0.90	1.78	....	140	1.09	0.751	1.90	400
		1.00	1.98	0.62	140	1.10	0.742	1.99	360
		1.10	2.18	....	141	1.11	0.740	2.02	310
		1.25	2.48	....	142	1.12	0.710	2.27	220
		1.50	2.98	....	143	1.14	0.715	2.28	160
1 : 5	25.7	0.80	1.00	....	143	1.07	0.788	1.13	1400
		0.90	1.13	....	143	1.09	0.786	1.17	1280
		1.00	1.25	0.75	141	1.12	0.786	1.20	1150
		1.10	1.38	....	142	1.11	0.786	1.19	950
		1.25	1.57	....	144	1.12	0.756	1.37	720
		1.50	1.88	....	144	1.15	0.740	1.50	460
1 : 3½	18.0	0.80	0.69	....	143	1.14	0.780	0.88	2410
		0.90	0.78	....	144	1.14	0.786	0.85	2320
		1.00	0.86	0.62	144	1.17	0.760	0.98	2270
		1.10	0.94	....	143	1.16	0.763	0.96	1960
		1.25	1.08	....	143	1.19	0.745	1.06	1600
		1.50	1.30	....	142	1.22	0.725	1.17	1110
FINENESS MODULUS, 5.50; SURFACE AREA, 1070; SURFACE MODULUS, 7.8.									
1 : 7	22.3	0.80	1.16	....	148	1.01	0.835	1.17	1290
		0.90	1.31	....	147	1.02	0.826	1.24	1010
		1.00	1.45	0.75	146	1.04	0.814	1.35	880
		1.10	1.59	....	147	1.05	0.816	1.35	500
		1.25	1.82	....	148	1.05	0.805	1.44	420
		1.50	2.17	....	147	1.07	0.794	1.54	320
1 : 5	15.9	0.80	0.78	....	150	1.03	0.845	0.80	2530
		0.90	0.89	....	150	1.04	0.840	0.83	2180
		1.00	0.97	0.62	149	1.06	0.821	0.93	1920
		1.10	1.07	....	148	1.06	0.824	0.93	1460
		1.25	1.22	....	147	1.09	0.805	1.06	910
		1.50	1.45	....	148	1.10	0.783	1.19	600
1 : 3½	11.2	0.80	0.58	....	149	1.09	0.839	0.61	3280
		0.90	0.64	....	149	1.10	0.830	0.65	3370
		1.00	0.72	0.62	149	1.10	0.830	0.65	2960
		1.10	0.80	....	149	1.13	0.807	0.76	2660
		1.25	0.90	....	147	1.15	0.795	0.83	1870
		1.50	1.08	....	147	1.17	0.785	0.88	1190

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[1] Square inches of aggregate per gram of cement.

[2] Volumes of concrete for one volume of aggregate.

TABLE IV.—COMPRESSION TESTS OF CONCRETE—(*Continued*).

FINENESS MODULUS, 5.75; SURFACE AREA, 900; SURFACE MODULUS, 6.6.

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per sq. in.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
1 : 7	18.4	0.80	1.08	....	150	0.98	0.856	0.99	1590
		0.90	1.23	....	150	0.98	0.856	0.99	1000
		1.00	1.36	0.62	149	1.01	0.835	1.17	790
		1.10	1.51	....	146	1.03	0.815	1.33	570
		1.25	1.70	....	148	1.03	0.815	1.33	480
		1.50	2.04	....	147	1.06	0.793	1.54	380
1 : 5	13.1	0.80	0.74	....	149	1.02	0.848	0.78	2480
		0.90	0.86	....	151	1.01	0.860	0.71	2450
		1.00	0.93	0.62	149	1.03	0.845	0.80	1860
		1.10	1.02	....	148	1.05	0.828	0.90	1420
		1.25	1.15	....	148	1.06	0.820	0.96	890
		1.50	1.39	....	147	1.10	0.790	1.15	580
1 : 3½	9.2	0.80	0.57	....	149	1.08	0.842	0.60	3730
		0.90	0.64	....	151	1.08	0.843	0.59	3640
		1.00	0.72	0.75	150	1.10	0.829	0.66	3380
		1.10	0.78	....	150	1.11	0.824	0.68	2560
		1.25	0.89	....	147	1.14	0.809	0.80	1940
		1.50	1.07	....	147	1.16	0.780	0.89	1170

FINENESS MODULUS, 6.00; SURFACE AREA, 730; SURFACE MODULUS, 5.3.

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Slump, in.	Unit Weight, lb. per sq. in.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
1 : 7	14.8	0.80	0.81	....	143	1.01	0.825	1.24	1440
		0.90	0.90	....	148	0.98	0.852	1.02	1720
		1.00	1.00	0.62	148	0.985	0.848	1.05	1380
		1.10	1.11	....	150	0.98	0.859	1.03	1030
		1.25	1.26	....	149	0.99	0.842	1.10	740
		1.50	1.52	....	149	1.00	0.834	1.16	560
1 : 5	10.6	0.80	0.70	....	151	1.00	0.876	0.62	2860
		0.90	0.79	....	150	1.01	0.848	0.77	2140
		1.00	0.89	0.62	150	1.02	0.844	0.80	1760
		1.10	0.99	....	149	1.04	0.828	0.89	1240
		1.25	1.12	....	147	1.06	0.815	0.98	870
		1.50	1.34	....	147	1.08	0.800	1.08	650
1 : 3½	7.4	0.80	0.57	....	149	1.09	0.829	0.65	3270
		0.90	0.64	....	151	1.06	0.848	0.56	3210
		1.00	0.70	0.75	149	1.08	0.840	0.60	2620
		1.10	0.78	....	147	1.11	0.814	0.72	2210
		1.25	0.89	....	146	1.16	0.780	0.89	1530
		1.50	1.05	....	146	1.14	0.790	0.84	970

[1] Square inches of aggregate per gram of cement.

[2] Volumes of concrete for one volume of aggregate.

TABLE IV.—COMPRESSION TESTS OF CONCRETE—(*Continued*).

FINENESS MODULUS, 6.25; SURFACE AREA, 550; SURFACE MODULUS, 4.0.

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per cu. ft.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
1 : 7	10.7	0.80	0.69	....	133	1.03	0.760	1.73	860
		0.90	0.78	....	137	1.01	0.790	1.56	1170
		1.00	0.87	0.75	140	0.99	0.790	1.46	1260
		1.10	0.95	....	142	1.00	0.800	1.40	1010
		1.25	1.08	....	144	0.99	0.805	1.35	890
		1.50	1.30	....	145	0.98	0.817	1.26	640
1 : 5	7.7	0.80	0.64	....	143	1.01	0.820	0.91	2010
		0.90	0.72	....	146	1.00	0.834	0.83	2020
		1.00	0.81	0.75	147	1.00	0.825	0.87	1680
		1.10	0.88	....	149	0.99	0.838	0.80	1260
		1.25	1.00	....	148	1.01	0.820	0.91	1000
		1.50	1.20	....	149	1.02	0.812	0.96	690
1 : 3½	5.4	0.80	0.57	....	150	1.03	0.840	0.58	3030
		0.90	0.64	....	150	1.04	0.834	0.60	2550
		1.00	0.72	0.62	148	1.06	0.816	0.68	2020
		1.10	0.79	....	147	1.09	0.790	0.80	1470
		1.25	0.93	....	146	1.11	0.783	0.84	1090
		1.50	1.08	....	146	1.13	0.770	0.91	800

FINENESS MODULUS, 6.50; SURFACE AREA, 380; SURFACE MODULUS, 2.7.

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Slump, in.	Unit Weight, lb. per cu. ft.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
1 : 7	7.1	0.80	0.63	....	130	1.02	0.760	1.71	840
		0.90	0.71	....	132	1.03	0.768	1.67	1040
		1.00	0.78	0.62	133	1.00	0.770	1.61	960
		1.10	0.87	....	135	0.99	0.780	1.53	800
		1.25	0.98	....	137	0.99	0.780	1.53	740
		1.50	1.16	....	137	1.00	0.768	1.62	530
1 : 5	5.1	0.80	0.53	....	132	1.05	0.755	1.29	1120
		0.90	0.60	....	137	1.02	0.778	1.13	1460
		1.00	0.66	0.75	138	1.01	0.785	1.09	1550
		1.10	0.72	....	141	1.01	0.788	1.07	1210
		1.25	0.82	....	144	0.98	0.813	0.92	1100
		1.50	0.99	....	145	0.99	0.804	0.97	710
1 : 3½	3.5	0.80	0.55	....	146	1.02	0.815	0.66	2480
		0.90	0.63	....	151	1.00	0.840	0.56	2210
		1.00	0.69	0.62	150	1.01	0.825	0.62	2040
		1.10	0.76	....	147	1.04	0.797	0.74	1640
		1.25	0.87	....	147	1.06	0.796	0.76	1240
		1.50	1.04	....	146	1.08	0.770	0.87	860

[1] Square inches of aggregate per gram of cement.

[2] Volumes of concrete for one volume of aggregate.

on aggregate; both briquette and compression tests of 2 by 4-in. cylinders were made at intervals throughout the period covered by the concrete tests.

TABLE V.—SUMMARY OF COMPRESSION TESTS OF CONCRETE.

(Department of Public Works, Philadelphia.)

(Rearrangement of Strength Tests in Table IV.)

Fineness Modulus.	Surface Area, sq. in. per lb. of aggregate.	Surface Modulus.	Compressive Strength, lb. per sq. in.						
			0.80[a]	0.90[a]	1.00[a]	1.10[a]	1.25[a]	1.50[a]	Average.
MIX 1 : 7 BY VOLUME.									
2.58	3090	22.6	210	240	220	190	140	90	180
4.50	1760	12.8	520	400	360	310	220	160	330
5.50	1070	7.8	1290	1010	880	500	420	320	740
5.75	900	6.6	1590	1000	790	570	480	380	800
6.00	730	5.3	1440	1720	1380	1030	740	560	1150
6.25	550	4.0	860	1170	1260	1010	890	640	970
6.50	380	2.7	840	1040	960	800	740	530	820
		Average	960	940	840	630	520	380	710
MIX 1 : 5 BY VOLUME.									
2.58	3090	22.6	480	440	460	370	340	200	380
4.50	1760	12.8	1400	1280	1150	950	720	460	1000
5.50	1070	7.8	2530	2180	1920	1460	910	600	1600
5.75	900	6.6	2480	2450	1860	1420	890	580	1610
6.00	730	5.3	2860	2140	1760	1240	870	650	1590
6.25	550	4.0	2010	2020	1680	1260	1000	690	1440
6.50	380	2.7	1120	1460	1550	1210	1100	710	1190
		Average	1840	1710	1480	1130	830	560	1260
MIX 1 : 3½ BY VOLUME.									
2.58	3090	22.6	960	1060	1120	970	770	520	900
4.50	1760	12.8	2410	2320	2270	1960	1600	1110	1940
5.50	1070	7.8	3280	3370	2960	2660	1870	1190	2560
5.75	900	6.6	3730	3640	3380	2560	1940	1170	2740
6.00	730	5.3	3270	3210	2620	2210	1530	970	2300
6.25	550	4.0	3030	2550	2020	1470	1090	800	1830
6.50	380	2.7	2480	2210	2040	1640	1240	860	1740
		Average	2740	2620	2340	1920	1430	950	2000

[a] Relative consistency of concrete.

Table IV contains data of concrete tests. Table V is a rearrangement of strength tests in Table IV.

The original report gave fineness modulus values only; in this abstract the surface area and surface modulus were computed also.

REPORT OF TESTS MADE BY UNIVERSITY OF TEXAS, AUSTIN, TEX.

This report covers tests in Group I, using four gradings of sand and pebble aggregates, mixtures 1 : 7, 1 : 5, 1 : 3½ by volume and four consistencies. The entire group was repeated using the method of rodding described by F. E. Giesecke in his paper on "Effect of Rodding Concrete" *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part II, p. 219 (1920). In these tests the concrete was rodded 5 times.

TABLE VI.—TESTS OF CEMENT.

(University of Texas.)

All tests made in accordance with the Standard Specifications and Tests for Portland Cement (C 9 - 21) of the American Society for Testing Materials.[1]

Cement.	Date Made.	Fineness Residue on 200-mesh Sieve.	Normal Consistency, per cent by weight.	Time of Setting. Initial. h. m.	Time of Setting. Final. h. m.	Tensile Strength of Briquettes, lb. per sq. in. 7 days.	Tensile Strength of Briquettes, lb. per sq. in. 28 days.	Soundness (over boiling water).
A	Sept. 30, 1920	24.0	21.5	2 50	5 00	283	368	O.K.
B	Sept. 21, 1920	20.0	22.5	1 20	3 45	295	387	O.K.
Mix[2]	Oct. 11, 1920	22.0	21.0	2 55	5 00	293	363	O.K.

[1] 1921 Book of A.S.T.M. Standards.

[2] A mixture of equal parts of cements A and B.

TABLE VII.—TESTS OF AGGREGATE.

(University of Texas.)

Sand from Colorado River.

Item.		Sand.	Medium Gravel.	Coarse Gravel.	Mixed[1] Gravel.	Mixed Concrete Aggregate.		
						48.2[a]	35.4[a]	22.5[a]
Sieve Analysis, amount coarser than each sieve, per cent by weight.	Sieve No. 100	100	100	100	100	100	100	100
	Sieve No. 48[b]	98	100	100	100	99	99	100
	Sieve No 28[b]	75	100	100	100	88	91	94
	Sieve No. 14[b]	46	100	100	100	74	81	88
	⅛-in	25	100	100	100	64	73	83
	¼-in	4	99	100	100	53	66	78
	⅜-in	0	70	100	84	44	55	65
	¾-in	..	6	96	50	26	32	39
	1½-in	..	0	8	4	2	3	3
Fineness modulus[2]		3.48	6.75	8.02	7.38	5.50	6.00	6.50
Surface area[2]		1720	140	50	95	880	670	460
Surface modulus[2]		12.5	1.0	0.4	0.7	6.4	4.9	3.4
Specific gravity		2.62	2.58	2.52	2.55	....	....	....
Absorption after 3-hr. immersion in water at room temperature		0.54	1.00	1.00	1.00	....	....	....
Unit weight, lb. per cu. ft		111	103	100	107	122	124	119
Organic impurities		Sand, light yellow in color (O.K.)						

[a] Sand, per cent by weight of total aggregate.

[b] Sieves No. 50, 30 and 16 have been substituted for No. 48, 28 and 14 in the Tentative Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 21 T).

[1] Equal parts by weight of the medium and coarse gravel.

[2] See text for explanation of these terms.

Concrete was hand-mixed, each batch forming one test piece. Specimens stored in damp sand and tested at 28 days. Four hundred and eighty 6 by 12-in. concrete cylinders were tested

TEST DATA.

The results of the tests are summarized in the attached tables. Table VI gives standard tests of the two cements and of the mixture which was used in the concrete. Table VII contains sieve analyses and other data on aggregate and Table VIII contains a summary of strengths of sand mortars; both briquette and compression tests of 2 by 4-in. cylinders were made at intervals throughout the period covered by the concrete tests.

TABLE VIII.—STRENGTH TESTS OF SAND MORTARS.

(University of Texas.)

Cement: a mixture of two brands of portland cement purchased in Austin.

Date Made.	Tension Tests of Briquettes, lb. per sq. in.						Compression Tests of 2 by 4-in. Cylinders, lb. per sq. in.					
	Mix 1 : 3 by Weight.				Mix 1 : 3 by Volume.		Mix 1 : 3 by Weight.				Mix 1 : 3 by Volume.	
	Standard Sand.		Colorado River Sand.		Colorado River Sand.		Standard Sand.		Colorado River Sand.		Colorado River Sand.	
	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.
Oct. 12, 1920	245	380	370	475	330	380	2220	2700	3210	4260	2740	3680
Oct. 13, 1920	300	340	355	445	350	450	1720	3020	3030	4700	2480	3580
Oct. 14, 1920	290	395	355	...	...	...	1980	2900	3320	6000	....	....
Nov. 5, 1920	285	425	390	500	340	455	1630	3070	3060	4060	2590	3950
Dec. 1, 1920	270	395	390	460	380	420	1900	3890	2740	4060	2280	3020
Dec. 13, 1920	270	370	325	425	305	390	1740	3160	2340	3710	1920	3240
Dec. 14, 1920	275	445	345	440	310	390	1770	3210	2560	3760	2120	3350
Dec. 16, 1920	275	400	395	505	335	430	1900	3350	3120	4560	2350	3370
Dec. 27, 1920	275	445	395	470	310	360	1820	3450	2900	4740	2330	3980
Jan. 12, 1921	275	490	375	475	330	440	2370	3900	2960	4560	2310	3650
Jan. 28, 1921	325	475	370	475	330	455	2240	3560	3020	5130	2720	4860
Jan. 31, 1921	310	495	385	515	340	455	2040	3980	3010	5390	2610	4120
Feb. 8, 1921	280	440	370	500	310	420	2460	4340	2820	5190	1980	4060
Feb. 11, 1921	330	415	400	525	345	430	2700	4240	4010	5400	3060	4500
Feb. 16, 1921	285	425	340	485	315	425	2180	4150	2920	4760	2600	4130
Average	285	420	370	480	330	420	2050	3530	3000	4630	2440	3820

Table IX contains data on concrete tests. Table X is a rearrangement of strength tests in Table IX.

The original report gave fineness modulus values only; in this abstract the surface area and surface modulus were computed also.

The original report contained detailed data on stress-deformation measurements on each cylinder. Only the modulus of elasticity of the concrete has been included in this summary. The exact method of determining these values was not stated.

TABLE IX.—COMPRESSION TESTS OF CONCRETE.

(University of Texas.)

Tests of 6 by 12-in. concrete cylinders.
Aggregate: sand and pebbles; — sand from the Colorado River.
Cement: a mixture of equal parts of two brands of portland cement purchased in Austin.
Specimens stored in damp sand until tested; tested damp at age of 28 days.
Each value is the average of 5 tests made on different days.
See text for explanation of fineness modulus, surface area and surface modulus.

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.											
				Molded by Standard Method.						Rodded.					
				Unit Weight, lb. per cu. ft.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.	Modulus of Elasticity.[3]	Unit Weight, lb. per cu. ft.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.	Modulus of Elasticity.[3]
FINENESS MODULUS OF AGGREGATE, 3.48; SURFACE AREA, 1720; SURFACE MODULUS, 12.5.															
1 : 7	31.4	0.90	1.44	132	1.02	0.731	1.92	490	1670	138	1.00	0.748	1.76	710	2260
		1.00	1.59	133	1.04	0.719	2.05	430	1760	136	1.00	0.747	1.77	710	2140
		1.10	1.75	134	1.04	0.718	2.06	390	1940	138	1.00	0.746	1.78	620	2200
		1.25	1.99	132	1.08	0.694	2.31	300	1180	137	1.02	0.736	1.89	520	2210
1 : 5	22.4	0.90	1.13	138	1.05	0.740	1.36	910	3040	143	1.00	0.770	1.15	1340	2680
		1.00	1.25	136	1.08	0.721	1.51	920	2060	142	1.00	0.765	1.17	1370	3730
		1.10	1.38	134	1.09	0.709	1.58	690	1840	141	1.00	0.772	1.14	1290	2780
		1.25	1.57	134	1.10	0.701	1.65	610	1850	142	1.00	0.772	1.14	1040	2540
1 : 3½	15.7	0.90	0.76	141	1.08	0.758	0.92	2120	3580	144	1.04	0.786	0.78	2850	3960
		1.00	0.86	140	1.10	0.751	0.96	1990	3790	145	1.04	0.796	0.75	2840	4320
		1.10	0.95	138	1.12	0.717	1.10	1830	3260	144	1.04	0.786	0.78	2520	4320
		1.25	1.08	137	1.13	0.732	1.06	1430	2340	145	1.05	0.786	0.79	2430	4940
FINENESS MODULUS OF AGGREGATE, 5.50; SURFACE AREA, 880; SURFACE MODULUS, 6.4.															
1 : 7	17.7	0.90	1.16	146	0.99	0.831	1.17	1090	3330	149	0.97	0.856	0.98	1810	4720
		1.00	1.29	146	1.00	0.828	1.20	1000	2960	150	0.96	0.857	0.96	1700	4270
		1.10	1.42	146	1.02	0.813	1.34	700	2420	149	0.97	0.855	0.98	1500	4360
		1.25	1.61	145	1.02	0.809	1.37	520	2620	149	0.97	0.853	1.00	1170	4040
1 : 5	12.6	0.90	0.714	148	1.02	0.843	0.80	2370	4620	151	0.99	0.861	0.69	3240	5120
		1.00	0.794	148	1.03	0.832	0.87	2210	3820	151	0.99	0.861	0.69	3180	4720
		1.10	0.874	147	1.04	0.825	0.91	2100	4190	150	1.01	0.850	0.76	3030	4800
		1.25	0.992	146	1.05	0.818	0.95	1630	3120	150	0.99	0.850	0.74	2620	4640
1 : 3½	8.8	0.90	0.549	148	1.06	0.842	0.59	3510	4300	150	1.05	0.856	0.53	4290	5100
		1.00	0.600	148	1.07	0.838	0.61	3520	4560	150	1.06	0.852	0.55	4180	5500
		1.10	0.659	148	1.08	0.828	0.65	3290	4660	150	1.06	0.849	0.56	3890	5010
		1.25	0.749	147	1.10	0.819	0.70	2550	4480	150	1.06	0.846	0.57	3420	4980

[1] Square inches of aggregate per gram of cement.

[2] Volumes of concrete for one volume of aggregate.

[3] Modulus of elasticity of concrete in 1000 lb. per sq. in.

TABLE IX—COMPRESSION TESTS OF CONCRETE—(*Continued*).

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.											
				Molded by Standard Method.						Rodded.					
				Unit Weight, lb. per cu. ft.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.	Modulus of Elasticity.[3]	Unit Weight, lb. per cu. ft.	Yield.[2]	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.	Modulus of Elasticity.[3]
FINENESS MODULUS OF AGGREGATE, 6.00; SURFACE AREA, 670; SURFACE MODULUS, 4.9.															
1 : 7	13.6	0.90	1.06	149	0.99	0.852	1.01	1180	3300	151	0.96	0.880	0.81	1970	4400
		1.00	1.19	148	0.99	0.853	1.02	920	3070	152	0.96	0.857	0.96	1950	3740
		1.10	1.30	149	1.00	0.839	1.13	720	2760	152	0.97	0.876	0.84	1710	4070
		1.25	1.48	147	1.00	0.831	1.19	580	2740	152	0.97	0.873	0.86	1210	3720
1 : 5	9.7	0.90	0.676	151	1.00	0.866	0.67	3120	5220	153	0.98	0.878	0.60	4000	5790
		1.00	0.748	150	1.00	0.859	0.71	2940	4550	153	0.98	0.882	0.58	3580	4930
		1.10	0.824	150	1.01	0.851	0.75	2430	4360	152	0.98	0.874	0.62	3680	5060
		1.25	0.938	149	1.02	0.844	0.79	1720	4280	152	0.99	0.874	0.62	3040	4370
1 : 3½	6.8	0.90	0.490	150	1.06	0.856	0.53	3760	5160	152	1.04	0.866	0.49	4480	5480
		1.00	0.550	150	1.07	0.845	0.58	3620	5180	152	1.05	0.866	0.49	4370	5770
		1.10	0.600	149	1.08	0.842	0.60	3440	4760	152	1.05	0.852	0.54	3940	5040
		4.25	0.690	148	1.09	0.832	0.64	2860	4330	151	1.05	0.862	0.51	3510	4570
FINENESS MODULUS OF AGGREGATE, 6.50; SURFACE AREA, 460; SURFACE MODULUS, 3.4.															
1 : 7	9.4	0.90	0.860	150	0.93	0.869	0.85	1560	3580	151	0.92	0.874	0.81	2060	3950
		1.00	0.953	150	0.93	0.869	0.85	1320	3880	151	0.91	0.879	0.77	1940	4740
		1.10	1.05	150	0.93	0.862	0.90	1070	3440	152	0.92	0.877	0.79	1620	3670
		1.25	1.19	148	0.95	0.843	1.04	850	3110	152	0.91	0.877	0.78	1330	4600
1 : 5	6.7	0.90	0.748	151	0.96	0.864	0.65	2500	4820	153	0.94	0.883	0.55	3290	5040
		1.00	0.819	150	0.97	0.852	0.72	1830	4290	153	0.95	0.879	0.57	2860	4710
		1.10	0.900	149	0.99	0.838	0.80	1470	3810	152	0.95	0.871	0.61	2380	4330
		1.25	1.025	149	1.01	0.827	0.87	1090	3890	152	0.95	0.871	0.61	1870	4340
1 : 3½	4.7	0.90	0.554	151	1.02	0.857	0.51	4040	5110	152	1.01	0.860	0.49	4490	5190
		1.00	0.613	151	1.03	0.847	0.55	3750	5170	152	1.01	0.864	0.48	4320	5180
		1.10	0.675	149	1.04	0.875	0.45	2910	3920	152	1.00	0.875	0.44	3670	5270
		1.25	0.768	149	1.06	0.820	0.67	2130	4400	151	1.02	0.860	0.50	3150	4820

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[1] Square inches of aggregate per gram of cement.

[2] Volumes of concrete for one volume of aggregate.

[3] Modulus of elasticity of concrete in 1000 lb. per sq. in.

TABLE X.—SUMMARY OF COMPRESSION TESTS OF CONCRETE.

(University of Texas.)

(Rearrangement of Strength Tests in Table IX.)

Fineness Modulus.	Surface Area, sq. in. per lb. of aggregate.	Surface Modulus.	Compressive Strength, lb. per sq. in.									
			Standard Method of Molding.					Rodded.				
			0.90[a]	1.00[a]	1.10[a]	1.25[a]	Average.	0.90[a]	1.00[a]	1.10[a]	1.25[a]	Average.
Mix 1 : 7 by Volume.												
3.48	1720	12.5	490	430	390	300	400	710	710	620	520	640
5.50	880	6.4	1090	1000	700	520	830	1810	1700	1500	1170	1540
6.00	670	4.9	1180	920	720	580	850	1970	1950	1710	1210	1710
6.50	460	3.4	1560	1320	1070	850	1200	2060	1940	1620	1330	1740
		Average	1080	920	720	560	820	1640	1580	1360	1060	1410
Mix 1 : 5 by Volume.												
3.48	1720	12.5	910	920	690	610	780	1340	1370	1290	1040	1260
5.50	880	6.4	2370	2210	2100	1630	2080	3240	3180	3030	2620	3020
6.00	670	4.9	3120	2940	2430	1720	2550•	4000	3580	3680	3040	3570
6.50	460	3.4	2500	1830	1470	1090	1720	3290	2860	2380	1870	2600
		Average	2220	1980	1670	1260	1780	2960	2750	2590	2140	2610
Mix 1 : $3\frac{1}{2}$ by Volume.												
3.48	1720	12.5	2120	1990	1830	1430	1840	2850	2840	2520	2430	2600
5.50	880	6.4	3510	3520	3290	2550	3220	4290	4180	3890	3420	3940
6.00	670	4.9	3760	3620	3440	2860	3420	4480	4370	3940	3510	4080
6.50	460	3.4	4040	3750	2910	2130	3210	4490	4320	3670	3150	3910
		Average	3360	3220	2870	2240	2920	4030	3910	3510	3130	3650

[a] Relative consistency of concrete.

REPORT OF TESTS MADE BY UNIVERSITY OF TORONTO, TORONTO, CANADA.

This report covers tests in Group II, except that the batches were proportioned on the basis of the *separate volumes* of aggregate, instead of by ***mixed volume.*** Seven gradings of sand and crushed stone aggregates were used for mixtures of 1 : 7, 1 : 5, and 1 : 3½, and each mixed to six consistencies. The mixtures designated as 1 : 7 vary from 1 : 7 to about 1 : 6 when converted in the form recommended by the committee; the 1 : 5 mixtures vary from 1 : 5 to about 1 : 4½, etc. The converted mixtures are given in Table XI.

TABLE XI.—TRUE MIX FOR CONCRETES IN TABLE XV.

(University of Toronto..)

Mix by Separate Volumes.	True Mix for Aggregates of Different Gradings.						
	4.00[a]	4.50[a]	5.50[a]	5.75[a]	6.00[a]	6.25[a]	6.50[a]
1 : 7	1 : 7.0	1 : 6.6	1 : 6.0	1 : 5.9	1 : 5.9	1 : 6.0	1 : 6.1
1 : 5	1 : 5.0	1 : 4.7	1 : 4.3	1 : 4.2	1 : 4.2	1 : 4.3	1 : 4.4
1 : 3½	1 : 3.5	1 : 3.3	1 : 3.0	1 : 2.9	1 : 2.9	1 : 3.0	1 : 3.1

[a] Fineness modulus of aggregates.

Concrete was hand mixed in batches of about $\frac{1}{5}$ cu. ft. Four hundred and thirteen 6 by 12-in. cylinders were tested. Specimens were stored in a moist place and tested damp at the age of 28 days.

The following is from Professor Gillespie's report, "In the time at our disposal we did not obtain figures for Unit Weight, Density or Yield, and we made only four cylinders of each batch in Group II."

TEST DATA.

The results of the tests are summarized in Tables XII to XV. Table XII gives standard tests of the portland cement which was used in the concrete. Table XIII gives the results of tension tests of briquettes and compression tests of 2 by 4-in. cylinders made of 1 : 3 mortar using both standard and "commercial" sand. Table XIV gives sieve analyses, mortar tests of sand and other data on the aggregates. Table XV contains data of compression tests of concrete cylinders.

The original report gave fineness modulus values only; in this abstract the surface area and surface modulus were computed also.

Sufficient data were not available to calculate the void-cement ratio as was done in abstracting the reports on tests made in Series 201 by other laboratories.

TABLE XII.—TESTS OF CEMENT.

(University of Toronto.)

All tests made in accordance with the Standard Specifications and Tests for Portland Cement (C 9 - 21) of the American Society for Testing Materials.[1]

Cement: a mixture of three brands of portland cement purchased in Toronto.

Fineness Residue on		Normal Consistency, per cent by weight.	Specific Gravity.	Time of Setting (Gillmore Needle).		Tensile Strength of Briquettes, lb. per sq. in.		Soundness Test (over boiling water).
				Initial.	Final.			
100	200			h. m.	h. m.	7 days.	28 days.	
0.2	3.5	23.5	3.04	1 10	5 27	245	385	O.K.

[1] 1921 Book of A.S.T.M. Standards.

TABLE XIII.—STRENGTH TESTS OF SAND MORTARS.

(University of Toronto.)

Cement: a mixture of three brands of portland cement purchased in Toronto.

Tension Tests of Briquettes, lb. per sq. in.						Compression Tests of 2 by 4-in. Cylinders, lb. per sq. in.					
Mix 1 : 3 by Weight.				Mix 1 : 3 by Volume.		Mix 1 : 3 by Weight.				Mix 1 : 3 by Volume.	
Standard Sand.		Commercial Sand.		Commercial Sand.		Standard Sand.		Commercial Sand.		Commercial Sand.	
7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.
245	385	475	508	407	468	1230	2150	1963	3480	1650	2260

TABLE XIV.—MISCELLANEOUS TESTS OF AGGREGATES.

(University of Toronto.)

Item.		Sand.	Crushed Stone.	Mixed Aggregate.					
				86[a]	57[a]	50[a]	43[a]	36[a]	29[a]
Sieve Analysis, amount coarser than each sieve, per cent by weight.	Sieve No. 100	97	99	97	98	98	98	98	98
	Sieve No. 48[b]	95	99	96	97	97	97	98	98
	Sieve No. 28[b]	93	99	94	96	96	96	97	97
	Sieve No. 14[b]	82	98	84	89	90	91	92	94
	Sieve No. 8	28	98	38	58	63	68	73	78
	Sieve No. 4	5	98	18	45	52	58	65	71
	$\frac{3}{8}$-in	0	93	13	40	46	53	60	66
	$\frac{3}{4}$-in	..	66	10	27	33	39	42	48
	$1\frac{1}{2}$-in	..	0	0	0	0	0	0	0
Fineness modulus		4.00	7.50	4.50	5.50	5.75	6.00	6.25	6.50
Surface area		1380	230	1220	860	800	750	640	580
Surface modulus		10.1	1.7	8.9	6.3	5.8	5.5	4.7	4.3
Specific gravity		2.63	2.74	....	....	....	....	....	....
Absorption after 3-hr. immersion in water at room temperature		0.5	0.4	....	....	....	....	....	....
Unit weight, lb. per cu. ft.		109	99	....	....	....	....	....	....
Organic impurities		Pale straw color (O.K.)							

[a] Sand, per cent of total aggregate.

[b] Sieves No. 50, 30 and 16 have been substituted for No. 48, 28 and 14 in the Tentative Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 21 T).

TABLE XV.—COMPRESSION TESTS OF CONCRETE.

(University of Toronto.)

Tests of 6 by 12-in. concrete cylinders.
Aggregate: sand and crushed limestone from Toronto.
Cement: a mixture of equal parts of three brands of portland cement purchased in Toronto.
Specimens stored in moist place until tested at age of 28 days.
Each value is the average of 4 tests made on different days.
See text for explanation of fineness modulus, surface area, and surface modulus.

Relative Consistency.	Mix 1 : 7 by Volume.[1]			Mix 1 : 5 by Volume.[1]			Mix 1 : $3\frac{1}{2}$ by Volume.[1]		
	Surface Area.[2]	Water Ratio.	Compressive Strength, lb. per sq. in.	Surface Area.[2]	Water Ratio.	Compressive Strength, lb. per sq. in.	Surface Area.[2]	Water Ratio.	Compressive Strength, lb. per sq. in.
FINENESS MODULUS, 4.00; SURFACE AREA, 1380; SURFACE MODULUS, 10.1.									
0.80	24.7	1.01	650	17.6	0.80	1160	12.3	0.65	2010
0.90	24.7	1.14	850	17.6	0.90	1390	12.3	0.73	2320
1.00	24.7	1.27	760	17.6	1.00	1450	12.3	0.81	2670
1.10	24.7	1.39	690	17.6	1.10	1370	12.3	0.89	2330
1.25	24.7	1.58	510	17.6	1.26	1100	12.3	1.01	1780
1.50	24.7	1.90	360	17.6	1.51	590	12.3	1.22	1120
FINENESS MODULUS, 4.50; SURFACE AREA, 1220; SURFACE MODULUS, 8.9.									
0.80	21.4	0.94	1040	15.3	0.76	1460	10.7	0.61	2370
0.90	21.4	1.06	1040	15.3	0.85	1700	10.7	0.69	3000
1.00	21.4	1.18	870	15.3	0.95	1690	10.7	0.77	2900
1.10	21.4	1.30	820	15.3	1.05	1530	10.7	0.85	2450
1.25	21.4	1.47	620	15.3	1.18	1120	10.7	0.96	1610
1.50	21.4	1.78	380	15.3	1.42	740	10.7	1.15	1060
FINENESS MODULUS, 5.50; SURFACE AREA, 860; SURFACE MODULUS, 6.3.									
0.80	14.8	0.81	1640	10.6	0.66	2570	7.4	0.56	2870
0.90	14.8	0.91	1820	10.6	0.74	3240	7.4	0.62	3670
1.00	14.8	1.01	1730	10.6	0.82	2870	7.4	0.69	3460
1.10	14.8	1.11	1470	10.6	0.91	2280	7.4	0.76	2610
1.25	14.8	1.27	970	10.6	1.03	1660	7.4	0.86	2300
1.50	14.8	1.52	590	10.6	1.24	1040	7.4	1.03	1420
FINENESS MODULUS, 5.75; SURFACE AREA, 800; SURFACE MODULUS, 5.8.									
0.80	13.8	0.77	1800	9.8	0.64	2660	6.9	0.53	3520
0.90	13.8	0.87	2170	9.8	0.72	3380	6.9	0.60	3770
1.00	13.8	0.97	1970	9.8	0.80	2920	6.9	0.67	3520
1.10	13.8	1.07	1550	9.8	0.88	2490	6.9	0.73	3360
1.25	13.8	1.22	1060	9.8	1.00	1770	6.9	0.83	2400
1.50	13.8	1.47	640	9.8	1.20	1000	6.9	1.00	1370

[1] These mixes are nominal only; the true mixes, in terms of mixed aggregates are given in Table XI.

[2] Square inches of aggregate per gram of cement.

TABLE XV.—COMPRESSION TESTS ON CONCRETE—(*Continued*).

Relative Consistency.	Mix 1 : 7 by Volume.[1]			Mix 1 : 5 by Volume.[1]			Mix 1 : $3\frac{1}{2}$ by Volume.[1]		
	Surface Area.[2]	Water Ratio.	Compressive Strength, lb. per sq. in.	Surface Area.[2]	Water Ratio.	Compressive Strength, lb. per sq. in.	Surface Area.[2]	Water Ratio.	Compressive Strength, lb. per sq. in.
FINENESS MODULUS, 6.00; SURFACE AREA, 750; SURFACE MODULUS, 5.5.									
0.80	12.7	0.74	2030	9.1	0.61	3000	6.4	0.51	3450
0.90	12.7	0.83	2300	9.1	0.69	3540	6.4	0.58	3920
1.00	12.7	0.93	2270	9.1	0.76	3170	6.4	0.65	3740
1.10	12.7	1.02	1780	9.1	0.84	2740	6.4	0.71	3390
1.25	12.7	1.16	1210	9.1	0.95	1970	6.4	0.81	2620
1.50	12.7	1.40	710	9.1	1.14	1060	6.4	0.97	1440
FINENESS MODULUS, 6.25; SURFACE AREA, 640; SURFACE MODULUS, 4.7.									
0.80	10.9	0.70	2060	7.8	0.58	2570	5.4	0.50	3780
0.90	10.9	0.79	2450	7.8	0.66	3580	5.4	0.56	4310
1.00	10.9	0.88	2080	7.8	0.73	3210	5.4	0.62	3870
1.10	10.9	0.97	1800	7.8	0.80	2620	5.4	0.69	3420
1.25	10.9	1.11	1200	7.8	0.91	1960	5.4	0.78	2730
1.50	10.9	1.33	730	7.8	1.10	1070	5.4	0.94	1550
FINENESS MODULUS, 6.50; SURFACE AREA, 580; SURFACE MODULUS, 4.3.									
0.80	9.2	0.67	1810	6.6	0.56	2430	4.6	0.48	3600
0.90	9.2	0.75	2500	6.6	0.63	3330	4.6	0.54	4170
1.00	9.2	0.84	2060	6.6	0.70	2690	4.6	0.60	3700
1.10	9.2	0.93	1900	6.6	0.78	2260	4.6	0.66	2950
1.25	9.2	1.06	1210	6.6	0.86	1600	4.6	0.75	2040
1.50	9.2	1.27	780	6.6	1.06	1060	4.6	0.90	1290

[1] These mixes are nominal only; the true mixes, in terms of mixed aggregates are given in Table XI.

[2] Square inches of aggregate per gram of cement.

REPORT OF TESTS MADE BY HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO, TORONTO, CANADA.

This report covers compression tests of concrete in Group II, using seven gradings of sand and crushed stone aggregates. Mixtures of 1 : 7, 1 : 5, and 1 : $3\frac{1}{2}$ in terms of volume of cement and mixed aggregate were used; each mix was tested in six different consistencies.

The concrete was hand mixed by means of shovels. Specimens were stored in a moist place and tested at 28 days. Six hundred and thirty 6 by 12-in. cylinders were tested.

TEST DATA.

The results of the tests are summarized in Tables XVI to XX. Table XVI gives standard tests of the portland cement which was used in the concrete. Table XVII gives the results of the chemical analyses of cement. Table XVIII gives the results of tension tests of briquette and compression tests of 2 by 4-in. cylinders made of 1 : 3 mortar using both standard and "Stamford" sand. Table XIX gives sieve analyses, mortar tests of sand and other data on the aggregate. Table XX contains data of compression tests of concrete cylinders.

TABLE XVI.—PHYSICAL TESTS OF CEMENT.

(Hydro-Electric Power Commission of Ontario.)

All tests made in accordance with the Standard Specifications and Tests for Portland Cement (C 9 - 21) of the American Society for Testing Materials.[1]

Cement: a brand purchased in Toronto.

Date Made.	Fineness Residue on 200.	Normal Consistency, per cent by weight.	Time of Setting (Vicat Needle).		Tensile Strength of Briquettes, lb. per sq. in.		Soundness Test (over boiling water).
			Initial. h. m.	Final. h. m.	7 days.	28 days.	
Mar. 3, 1920	....	23	.. ..	.. ..	252	388	O.K.
July 29, 1920	13.4	24	1 30	6 00	268	359	O.K
Oct. 21, 1920	15.0	24	2 50	6 50	291	420	O.K.
Jan. 10, 1921	21.8	24.5	2 00	7 00	242	343	O.K.
Jan. 18, 1921	8.6[a]	23.5[a]	3 00[a]	6 00[a]	215[a]	342[a]	O.K.[a]

[a] Small lot secured in separate shipment after original supply was exhausted.

[1] 1921 Book of A.S.T.M. Standards.

TABLE XVII.—CHEMICAL ANALYSIS OF CEMENT.

(Hydro-Electric Power Commission of Ontario.)

Compound.	Per cent.
Silica (SiO_2)	22.43
Iron and Aluminum Oxides (R_2O_3)	8.90
Lime (CaO)	62.08
Magnesia (MgO)	2.09
Sulfuric Anhydride (SO_3)	1.61
Loss on Ignition (CO_2+H_2O)	1.80
	98.91

The following is quoted from the original report:

"Our experience with the slump tests is that at least for crushed rock mixtures it cannot be depended upon to give comparative results with different proportions and gradings and that in work of this kind dependence must be placed on the judgment of an experienced operator as to when mixtures of equal consistency are obtained. Slump test measurements were made at normal or 100 per cent relative consistency, but only as a guide and not to determine the water to be used in gaging."

TABLE XVIII.—STRENGTH TESTS OF SAND MORTARS.

(Hydro-Electric Power Commission of Ontario.)

Cement: a brand purchased in Toronto.
1 : 3 mix by weight or volume.

Tension Tests of Briquettes, lb. per sq. in.						Compression Tests of 2 by 4-in. Cylinders, lb. per sq. in.					
Mix by Weight.				Mix by Volume.		Mix by Weight.				Mix by Volume.	
Standard Sand.		Stamford Sand.		Stamford Sand.		Standard Sand.		Stamford Sand.		Stamford Sand.	
7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.
270	325	365	450	295	...	395	600	1940	2350	1825	2590
275	325	420	460	345	400	705	605	1925	2120	1275	1695
280	370	400	510	300	415	470	815	1445	1950	1445	1850
245	355	385	...	350	...	715	715	1680	2325	1100	1460
245	340	330	535	280	425	...	855	1650	....	1400	1510
...	320	400	450	330	390	385	650	1750	2520	1545	2110
270	340	425	540	295	355	515	625	2375	4080	1450	2500
220	290	400	415	330	405	460	895	1940	3565	1355	1400
235	320	...	...	...	...	665	770	....	2610	1630	1540
255	...	330	425	330	450	655	730	1415	2240	1475	1950
Av. 255	330	385	475	315	405	550	725	1790	2640	1450	1860

TABLE XIX.—MISCELLANEOUS TESTS OF AGGREGATES.

(Hydro-Electric Power Commission of Ontario.)

Item.		Sand.	Crushed Stone.	Mixed Aggregate.					
				82.3[a]	56.3[a]	49.8[a]	43.3[a]	36.7[a]	30.3[a]
Sieve Analysis, amount coarser than each sieve, per cent by weight.	Sieve No. 100	99	100	99	99	99	100	100	100
	Sieve No. 48[b]	93	100	94	96	97	97	97	98
	Sieve No. 28[b]	77	100	81	87	88	90	92	93
	Sieve No. 14[b]	58	100	66	76	79	82	85	87
	Sieve No. 8	38	100	49	65	69	73	78	81
	Sieve No. 4	17	100	32	54	58	64	69	77
	$\frac{3}{8}$-in	0	100	17	44	51	57	62	68
	$\frac{3}{4}$-in	0	67	12	29	34	38	42	46
	$1\frac{1}{2}$-in	0	0	0	0	0	0	0	0
Fineness modulus		3.82	7.67	4.50	5.50	5.75	6.00	6.25	6.50
Surface area[1]		1720	71	1435	1036	921	764	640	545
Surface modulus		12.56	0.52	10.49	7.57	6.74	5.58	4.75	4.01
Specific gravity		2.64	2.82	2.67	2.72	2.73	2.74	2.75	2.77
Absorption after 3-hr. immersion in water at room temperature		1.28	1.50	....	....	....	....	....	....
Unit weight, lb. per cu. ft.		112	97	120	126	126	126	124	121
Organic impurities		low	......	....	....	....	....	....	....

[a] Sand, per cent by weight of total aggregate.

[b] Sieves No. 50, 30 and 16 have been substituted for No. 48, 28 and 14 in the Tentative Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 21 T).

[1] Square inches per pound.

TABLE XX.—COMPRESSION TESTS OF CONCRETE.

(Hydro-Electric Power Commission of Ontario.)

Tests of 6 by 12-in. concrete cylinders.

Aggregate: sand from Stamford, Ont., and crushed stone from power canal excavation, Niagara, Canada.

Cement: a brand purchased in Toronto.

In general the tests were made in accordance with "Outline of Compression Tests of Concrete;" see *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 294 (1920).

Specimens stored in moist place until tested at age of 28 days.

See text for explanation of fineness modulus, surface area, and surface modulus.

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per cu. ft.	Yield.	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
FINENESS MODULUS OF AGGREGATE, 3.82; SURFACE AREA, 1720; SURFACE MODULUS, 12.6.									
1 : 7	31.5	0.80	1.20	...	125	1.09	0.687	2.39	490
		0.90	1.37	...	127	1.08	0.692	2.31	460
		1.00	1.49	0	131	1.06	0.708	2.18	500
		1.10	1.68	...	135	1.04	0.720	2.04	510
		1.25	1.90	...	136	1.05	0.716	2.11	590
		1.50	2.24	...	134	1.08	0.691	2.39	340
1 : 5	22.2	0.80	0.91	...	127	1.12	0.694	1.71	1040
		0.90	1.05	...	129	1.11	0.700	1.67	760
		1.00	1.14	0.1	134	1.08	0.719	1.52	1120
		1.10	1.28	...	140	1.05	0.739	1.37	1010
		1.25	1.46	...	137	1.09	0.713	1.56	930
		1.50	1.70	...	136	1.12	0.694	1.71	770
1 : 3½	15.8	0.80	0.71	...	131	1.16	0.703	1.21	1630
		0.90	0.82	...	136	1.13	0.720	1.11	1440
		1.00	0.89	0.4	140	1.11	0.735	1.03	2220
		1.10	1.01	...	141	1.11	0.735	1.03	1750
		1.25	1.16	...	138	1.16	0.703	1.21	1280
		1.50	1.33	...	139	1.17	0.700	1.23	1280
FINENESS MODULUS OF AGGREGATE, 4.50; SURFACE AREA, 1440; SURFACE MODULUS, 10.5.									
1 : 7	28.3	0.80	1.13	...	136	1.06	0.744	1.90	860
		0.90	1.31	...	135	1.07	0.736	1.98	690
		1.00	1.41	0.1	140	1.04	0.758	1.76	820
		1.10	1.60	...	143	1.03	0.761	1.69	640
		1.25	1.82	...	140	1.07	0.736	1.98	640
		1.50	2.11	...	140	1.09	0.720	2.11	390
1 : 5	20.2	0.80	0.86	...	136	1.10	0.743	1.41	1610
		0.90	1.00	...	138	1.10	0.746	1.40	1170
		1.00	1.07	0.3	142	1.07	0.762	1.27	1800
		1.10	1.22	...	142	1.09	0.753	1.35	1300
		1.25	1.40	...	141	1.11	0.736	1.46	1170
		1.50	1.61	...	141	1.13	0.725	1.55	860
1 : 3½	14.2	0.80	0.67	...	136	1.17	0.735	1.08	2030
		0.90	0.79	...	144	1.12	0.768	0.91	2180
		1.00	0.84	0.8	144	1.12	0.764	0.93	3600
		1.10	0.96	...	143	1.15	0.746	1.02	2170
		1.25	1.10	...	142	1.17	0.733	1.09	1780
		1.50	1.26	...	144	1.18	0.730	1.12	1420

[1] Square inches of aggregate per gram of cement.

TABLE XX.—COMPRESSION TESTS OF CONCRETE—(*Continued*).

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per cu. ft.	Yield.	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
FINENESS MODULUS OF AGGREGATE, 5.50; SURFACE AREA, 1040; SURFACE MODULUS, 7.6.									
1 : 7	21.5	0.80	1.00	...	144	1.03	0.787	1.54	1500
		0.90	1.17	...	146	1.03	0.787	1.54	1210
		1.00	1.24	0	146	1.03	0.787	1.54	1260
		1.10	1.43	...	146	1.04	0.780	1.61	920
		1.25	1.62	...	145	1.06	0.765	1.74	760
		1.50	1.87	...	145	1.08	0.751	1.88	570
1 : 5	15.3	0.80	0.76	...	144	1.07	0.784	1.15	2130
		0.90	0.90	...	149	1.05	0.800	1.05	1940
		1.00	0.96	0.3	149	1.05	0.800	1.05	2460
		1.10	1.10	...	148	1.07	0.784	1.15	1640
		1.25	1.25	...	146	1.10	0.762	1.31	920
		1.50	1.43	...	148	1.10	0.762	1.31	1060
1 : 3½	10.7	0.80	0.60	...	143	1.14	0.772	0.91	2650
		0.90	0.71	...	148	1.12	0.786	0.84	2790
		1.00	0.75	0.2	150	1.11	0.794	0.80	4150
		1.10	0.87	...	149	1.13	0.780	0.87	2270
		1.25	0.99	...	148	1.15	0.766	0.94	1800
		1.50	1.13	...	148	1.17	0.753	1.01	1460
FINENESS MODULUS OF AGGREGATE, 5.75; SURFACE AREA, 920; SURFACE MODULUS, 6.7.									
1 : 7	19.0	0.80	0.96	...	144	1.03	0.785	1.55	1520
		0.90	1.12	...	147	1.01	0.800	1.41	1310
		1.00	1.19	0.4	149	1.01	0.800	1.41	1290
		1.10	1.37	...	148	1.02	0.788	1.52	710
		1.25	1.55	...	146	1.05	0.769	1.70	830
		1.50	1.79	...	146	1.06	0.762	1.77	610
1 : 5	13.6	0.80	0.73	...	145	1.06	0.788	1.12	2340
		0.90	0.86	0.3	148	1.05	0.797	1.07	1800
		1.00	0.92	0.5	151	1.03	0.811	0.97	2270
		1.10	1.06	0.3	149	1.06	0.789	1.12	1430
		1.25	1.20	0.6	148	1.08	0.774	1.22	1050
		1.50	1.37	4.9	148	1.09	0.767	1.27	1010
1 : 3½	9.5	0.80	0.58	...	142	1.15	0.763	0.96	2330
		0.90	0.69	...	149	1.11	0.791	0.81	3300
		1.00	0.82	0.4	151	1.11	0.791	0.81	4650
		1.10	0.84	...	149	1.13	0.777	0.88	2180
		1.25	0.96	...	148	1.15	0.763	0.96	1500
		1.50	1.09	...	150	1.15	0.763	0.96	1490

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[1] Square inches of aggregate per gram of cement.

TABLE XX.—COMPRESSION TESTS OF CONCRETE—(*Continued*).

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per cu. ft.	Yield.	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
FINENESS MODULUS OF AGGREGATE, 6.00; SURFACE AREA, 760; SURFACE MODULUS, 5.6.									
1 : 7	15.8	0.80	0.91	...	145	1.02	0.790	1.50	1560
		0.90	1.07	...	148	1.01	0.798	1.43	1490
		1.00	1.14	0	150	1.00	0.806	1.36	1370
		1.10	1.30	...	149	1.01	0.798	1.43	960
		1.25	1.48	...	147	1.04	0.775	1.64	860
		1.50	1.70	...	146	1.06	0.760	1.78	690
1 : 5	11.3	0.80	0.70	...	146	1.05	0.793	1.09	2330
		0.90	0.82	...	150	1.03	0.809	0.98	1940
		1.00	0.88	0.5	152	1.02	0.817	0.93	2600
		1.10	1.01	...	150	1.05	0.795	1.08	1640
		1.25	1.15	...	148	1.08	0.772	1.23	1060
		1.50	1.31	...	148	1.09	0.765	1.28	1020
1 : 3½	7.9	0.80	0.56	...	142	1.15	0.760	0.97	2000
		0.90	0.66	...	150	1.10	0.795	0.79	3800
		1.00	0.69	0.8	151	1.09	0.802	0.75	4250
		1.10	0.81	..	050	1.12	0.781	0.86	2480
		1.25	0.92	...	149	1.14	0.767	0.93	1510
		1.50	1.04	...	150	1.14	0.767	0.93	1380
FINENESS MODULUS OF AGGREGATE, 6.25; SURFACE AREAS, 650; SURFACE MODULUS, 4.8.									
1 : 7	13.2	0.80	0.85	...	144	1.00	0.784	1.53	1600
		0.90	1.00	...	148	0.99	0.800	1.39	1480
		1.00	1.06	...[2]	149	0.98	0.810	1.30	1250
		1.10	1.22	...	150	0.98	0.810	1.30	1060
		1.25	1.38	...	147	1.01	0.782	1.54	880
		1.50	1.59	...	147	1.02	0.775	1.61	700
1 : 5	9.5	0.80	0.66	...	145	1.04	0.788	1.10	1960
		0.90	0.78	...	150	1.02	0.803	1.01	2070
		1.00	0.82	0.4	151	1.01	0.811	0.95	2440
		1.10	0.95	...	150	1.03	0.795	1.06	1440
		1.25	1.08	...	151	1.04	0.788	1.10	1040
		1.50	1.23	...	151	1.05	0.780	1.16	1060
1 : 3½	6.6	0.80	0.53	...	140	1.14	0.754	0.98	1640
		0.90	0.63	...	151	1.07	0.803	0.74	3370
		1.00	0.66	0.6	153	1.06	0.812	0.70	4100
		1.10	0.77	...	150	1.10	0.782	0.84	2110
		1.25	0.88	...	150	1.11	0.775	0.88	1590
		1.50	0.99	...	150	1.12	0.768	0.91	1320

[1] Square inches of aggregate per gram of cement.

[2] Material fell apart before measurement could be made.

TABLE XX.—COMPRESSION TESTS OF CONCRETE—(*Continued*).

Mix by Volume.	Surface Area.[1]	Relative Consistency.	Water Ratio.	Concrete Tests.					
				Slump, in.	Unit Weight, lb. per cu. ft.	Yield.	Density.	Void-Cement Ratio.	Compressive Strength, lb. per sq. in.
FINENESS MODULUS OF AGGREGATE, 6.50; SURFACE AREA, 540; SURFACE MODULUS, 4.0.									
1 : 7	10.8	0.80	0.79	...	150	0.94	0.818	1.20	1460
		0.90	0.92	...	146	0.97	0.792	1.41	1390
		1.00	0.98	...[2]	150	0.95	0.810	1.25	1110
		1.10	1.13	...	150	0.97	0.793	1.41	920
		1.25	1.29	...	146	1.00	0.769	1.62	890
		1.50	1.48	...	148	1.00	0.769	1.62	820
1 : 5	7.7	0.80	0.62	...	141	1.04	0.765	1.22	1700
		0.90	0.73	...	150	0.99	0.805	0.97	2150
		1.00	0.77	...	150	1.00	0.797	1.01	2120
		1.10	0.89	...	151	1.00	0.797	1.01	1560
		1.25	1.01	...	149	1.02	0.780	1.12	1120
		1.50	1.15	...	150	1.03	0.773	1.17	1050
1 : 3.5	5.4	0.80	0.50	...	140	1.12	0.747	0.99	1790
		0.90	0.60	...	151	1.05	0.800	0.74	2900
		1.00	0.63	0.3	152	1.05	0.798	0.74	3930
		1.10	0.73	...	150	1.07	0.782	0.82	2030
		1.25	0.82	...	150	1.08	0.776	0.85	1250
		1.50	0.94	...	150	1.10	0.762	0.92	1320

[1] Square inches of aggregate per gram of cement.

[2] Material fell apart before measurement could be made.

REPORT OF COMMITTEE C-10

ON

HOLLOW BUILDING TILE.

The work that has occupied Committee C-10 since the last annual meeting of the Society is that connected with the revision of the Tentative Definitions of Terms relating to Hollow Building Tile (C 43 - 21 T), the revision or change of status of the Tentative Specifications for Clay Hollow Building Tile (C 34 - 21 T), and new work on the preparation of specifications for fireproofing.

The committee received a communication from Committee E-8 on Nomenclature and Definitions, containing some constructive suggestions as to changes in the Tentative Definitions of Terms Relating to Hollow Tile (C 43 - 21 T), to reconcile them with the principles that are now being followed by Committee E-8 in placing the definitions of the Society on a uniform basis. Committee C-10 has given consideration to the suggestions of Committee E-8 and in most instances has accepted them. It has made some additional revisions and has reworded its definitions accordingly, placing them in the hands of Committee E-8 for further action. An exception should be noted, however, in the case of the definitions for shale, surface clay and fireclay on account of these having been referred by Committee E-8 to a special sub-committee.

Committee C-10 recommends that the Tentative Specifications for Clay Hollow Building Tile (C 34 - 21 T) accepted as tentative last year, remain tentative without change. It was decided that inasmuch as any revisions which may be recommended will be based, in a large measure, on the results of the cooperative investigation of the properties of hollow tile, with special reference to fire resistance, that is being carried on at the Bureau of Standards, the revisions should not be made until the data from portions of this investigation which are nearing completion are available.

At the first meeting of the committee, a sub-committee to be known as Sub-Committee VI on Fireproofing was appointed to draft specifications for fireproofing. The sub-committee has kept in touch with the progress of the cooperative investigation referred to and recommends that the drafting of specifications for fireproofing be postponed until additional test data are available.

This report has been submitted to letter ballot of the committee, which consists of 14 members, of whom 12 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee.

W. A. Hull,
Chairman.

C. C. Crockatt,
Secretary.

REPORT OF COMMITTEE C-11
ON
GYPSUM.

The schedule of three meetings a year, to which this committee is now working, has proven so satisfactory that it is thought worth while to bring it to the attention of the Society. At the meeting held in connection with the annual meeting of the Society, plans for the next year's work are laid. The second meeting, in October, is for the purpose of considering preliminary reports and suggesting changes in the program. At the third meeting, in March, final reports are received and conclusions adopted.

The substance of this report is a sufficient indication that the committee has been extremely active. Three new members have been added during the year, and a new sub-committee, on the fire-resistive properties of gypsum products, has been organized. Owing to the interlocking membership, it is believed that this sub-committee will cooperate closely with Committee C-5 on Fireproofing.

As to the various tentative specifications over which this committee has jurisdiction, it recommends that the Society take action as indicated:

Tentative Specifications for Gypsum (*C 22 - 21 T*).[1]—The committee recommends that these specifications be revised as follows:

"*Section 2.* (*c*).—Change to read as follows by the insertion of the italicized words and figures and the omission of the words and figures in brackets:

"No material may be considered gypsum within the meaning of these specifications which contains [more] *less* than [35.5] *64.5* per cent by weight of [impurities] $CaSO_4 \cdot 2H_2O$."

Section 3.—Change Paragraph (*b*) from its present form: namely,

"*Crushed.*—Run-of-mine gypsum further reduced to sizes suitable for specific uses. Crushed gypsum may be marketed in either of the following sizes:

"No. 1.—Material of this size shall all pass through a 3-in. (7.6-cm.) ring; not more than 30 per cent shall pass through a 100-mesh screen, and not less than 40 per cent shall be retained on a $\frac{3}{16}$-in. (0.469-cm.) or equal mesh screen.

"No. 2.—Material of this size shall pass through a 2-in. (5.08-cm.) ring; not more than 30 per cent shall pass through a 100-mesh screen, and not less than 10 per cent shall be retained on a $\frac{3}{16}$-in. (0.469-cm.) or equal mesh screen."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 553 (1921).

to read as follows:

> "*Crushed.*—Run-of-mine gypsum further reduced so that all of it will pass through a 2-in. (50.8 mm.) ring, and not less than 10 per cent shall be retained on a No. 3 sieve."

Insert a new Paragraph (*c*) to read as follows:

> "(*c*) *Crushed Gypsum, Sized.*—Shall all pass a No. 3 sieve, and not less than 10 per cent shall be retained on a No. 8 sieve."

Change the present Paragraph (*c*) to Paragraph (*d*).

Section 5.—Change to read as follows by the insertion of the italicized words:

> "When gypsum is shipped in bulk, samples of about 5 lb. (2.25 kg.) each shall be taken at regular intervals during the complete loading or unloading of the carrier, in such a way as to accumulate at least 200 lb. (90 kg.) of material, *and to represent correctly the percentages of both the coarse particles and the fines in the shipment.* This shall be broken so that it will all pass a 1-in. (25-mm.) ring, thoroughly mixed, and reduced by quartering to provide not less than a 1-lb. (0.5-kg.) sample for the laboratory."

The committee recommends that the tentative specifications as revised be continued as tentative, the letter ballot vote of the committee on this recommendation being as follows: Affirmative, 26; negative, 1; not voting, 7.

Tentative Specifications for Calcined Gypsum (C 23 – 21 T).[1]—The committee recommends that these specifications be revised as follows:

Section 4 (b).—Omit this paragraph reading as follows:

> "Calcined gypsum for molding or casting shall all pass a 14-mesh sieve and not less than 75 per cent of it shall pass a 100-mesh sieve."

Sections 5 and 6.—Omit these sections relating to color and plasticity, respectively, both reading as follows:

> "Specifications to be supplied by the committee when the information is available."

Add a footnote to read as follows:

> "Specifications for the color and plasticity of calcined gypsum will be supplied when the information is available."

The committee recommends that with these revisions the specifications be adopted as standard, the letter ballot vote on this recommendation being as follows: Affirmative, 23; negative, 2; not voting, 9.

Tentative Specifications for Gypsum Plastering Sand (C 35 – 21 T).—The committee recommends that these specifications be continued as tentative without revision.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 556 (1921).

Tentative Specifications for Gypsum Wall Board (C 36 - 21 T).[1]—As a result of an intensive study of gypsum wall board during the year, many changes in the specifications for this material have been found desirable. The Tentative Specifications for Gypsum Wall Board have accordingly been rewritten and are appended hereto in their proposed revised form.[2] The committee recommends that the specifications, as rewritten, be accepted for publication to replace the present tentative specifications for gypsum wall board. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 26; negative, 0; not voting, 8.

Tentative Specifications for Gypsum Plaster Board (C 37 - 21 T).[3]—As a result of an intensive study of gypsum plaster board during the year, many changes in the specifications for this material have been found desirable. The Tentative Specifications for Gypsum Plaster Board have accordingly been rewritten and are appended hereto in their proposed revised form.[4] The committee recommends that the specifications, as rewritten, be accepted for publication to replace the present tentative specifications for gypsum plaster board The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 26; negative, 0; not voting, 8.

Tentative Methods of Testing Gypsum and Gypsum Products (C 26 - 21 T).—While certain changes in a few of these methods seem to be desirable, no action has as yet been decided upon, and the methods are now under the jurisdiction of Committee E-1 on Methods of Testing. For these reasons it is recommended that they be continued, without change, as tentative for another year.

Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 21 T).[5]—At the recommendation of Committee E-8, it is desired that some of these terms be withdrawn, and others be reworded. One new definition, for the term "lath," should be added. A revised list of these definitions is appended hereto,[6] and it is recommended that these definitions be accepted for publication as tentative to replace the present Tentative Definitions. The vote of the committee is as follows: Affirmative, 27; negative, 0; not voting, 7.

Besides the work indicated by the above conclusions, much experimental work has been done during the year and is still in active progress. This includes the study of such subjects as the value of anhydrite as a retarder for portland cement, the adhesion of gypsum plaster to concrete, development of a chemical method for the determination of anhydrite in gypsum, improvements in the apparatus for making the slump test for consistency, and further information about the characteristics of good plastering sand.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 560 (1921).

[2] See p. 710.—ED.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 562 (1921).

[4] See p. 712.—ED.

[5] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 600 (1921).

[6] See p. 732.—ED.

Subjects which have been and still are matters for discussion rather than experiment include the requirement as to sizes of crushed gypsum, the requirement as to purity of gypsum, methods of test for the color and the plasticity of calcined gypsum, method for the determination of SO_3 in gypsum, and the utilization of the microscope in the examination of gypsum products.

Work which has recently been started includes the development of specifications for gypsum tile, development of information about the acoustical properties of gypsum plaster and the fire-resistive properties of all gypsum products, and development of the data necessary for the design of reinforced gypsum roofs and floors.

This report has been submitted to letter ballot of the committee, which consists of 34 members, of whom 28 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee.

W. E. EMLEY,
Chairman.

V. G. MARANI,
Secretary.

EDITORIAL NOTE.

The Tentative Specifications for Calcined Gypsum amended as indicated in this report were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1922.

The proposed revisions of the Tentative Specifications for Gypsum, of the Tentative Specifications for Gypsum Wall Board and of the Tentative Specifications for Gypsum Plaster Board referred to in this report were accepted. The specifications as thus revised appear on pages 707–714. The proposed revisions of the Tentative Definitions of Terms Relating to Gypsum were accepted. The definitions as thus revised appear on page 732.

A paper by J. M. Porter on "Gypsum Plaster and Wall Boards" was accepted at the annual meeting for publication as an appendix to this report and appears on page 358.

APPENDIX.

GYPSUM PLASTER AND WALL BOARDS.

By J. Miller Porter.[1]

Gypsum plaster board may be defined as a lath or backing for plaster or stucco. It consists essentially of one or more layers of gypsum plaster and alternate layers of a fibrous material, such as chip or news stock. The gypsum plaster contains varying amounts of finely chipped wood, fiber or a similar material. The filler of chip or fiber acts to reduce the brittleness and hence the plaster boards may be nailed directly to the supports. The majority of gypsum plaster boards consist of only one layer of plaster between two layers of news stock, or similar material, though there are several manufacturers of the multi-ply board. The nominal thickness of plaster boards ranges from $\frac{1}{4}$ to $\frac{1}{2}$ in. The width is usually 32 in. and the length 36 in. The surfaces of the boards are left rough and the finish is not sized so as to give a good bond for the application of the plaster or stucco.

Gypsum wall boards may be defined as boards which are attached to the structural supporting members and constitute a finished surface which may be further decorated but should not be plastered.

Gypsum wall board is very similar in construction to gypsum plaster board in that it contains a layer of hydrated calcined gypsum between two layers of a fibrous material. In view of the fact that wall board is intended to be used as the finished wall, one side of the board is sized and is smooth. For the same reason that chip, fiber, etc., are used in plaster board, are they also used in wall board. It is made in widths varying from 32 to 48 in. and the thickness is $\frac{3}{8}$ in. The lengths are usually specified and depend upon the dimensions of the room in which it is to be used. On walls it is erected in vertical strips and horizontal joints are thereby eliminated. The joints may be covered in several ways. The most generally used methods are, first, by covering without any further treatment with wooden strips so as to give a paneled effect, or by the use of gummed paper strips of the same color as the wall board itself; or, second, when the joints are butted, by concealing them with plastic material furnished by the manufacturer and applied with a decorator's putty knife, and when the joints are open by filling the space with plaster. Joints concealed or filled in the manner described are visible only upon the closest inspection, and can not be located if the wall boards receive further decoration or are subsequently covered with wall paper. Wall boards designed to be erected with open joints that are to be filled with plaster have rounded edges so as to provide a key or clinch for the filling.

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[1] Chemical Engineer, Gypsum Industries Association.

The data for this article were obtained from boards submitted to the U. S. Bureau of Standards by the different manufacturers. About 90 per cent of the manufacturers were represented by the samples submitted. At least five specimens of each size and brand were tested to obtain an average.

The measurements that were made on both the wall and plaster boards were weight per unit area, necessary dimensions and strength.

As length and width would in themselves be taken care of by the method of manufacture, the only dimension that need be considered in detail would be thickness. In order to arrive at any definite conclusion, each board was measured at five different places: the center and at a point 2 in. from each corner along the diagonals. These measurements were made to the nearest 0.001 in. and from these we were able to study the local variations in each board and also to consider the average thicknesses.

In determining the weight of both plaster and wall boards, each board was weighed separately and then the weight per thousand square feet calculated from this.

Several methods for strength were considered but it was finally decided that the best method was to take 24 by 12-in. samples supported on knife edges 20 in. on centers and the load applied to the sample through two knife edges 8 in. from each supporting knife edge, at a rate of 25 to 30 lb. per minute. The reason for adopting two knife edges rather than one was that in using only one there was very little if any room for the paper to pull away from the core even though the tendency was there. Using two, this can result if there is cause and it can be noted if it does happen. Attention might be called to the fact that the method of testing by the use of two knife edges, while not that recommended by Committee C-11, as far as stresses set up in the board are involved, is the same, and was used only in preference to one knife edge so that the method of failure may be noted more definitely.

It was soon realized that the strength of the boards is very much affected by the direction in which the strength was measured, that is, whether the knife edges were parallel or across the grain of the fiber surface. This at once brought up the question, "What effect does the surface have on the strength of the board?" It was obvious that it must have a very marked effect, especially when it was noted that the strength in the two directions of the fiber used as surface was almost exactly proportional to the strength of the board in the two directions.

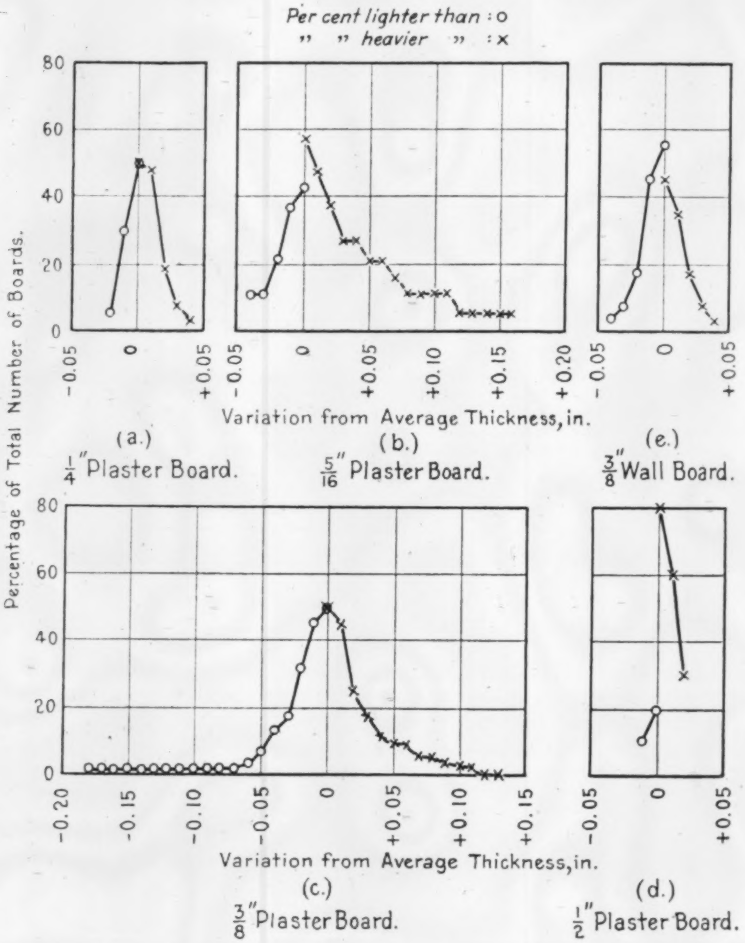

FIG. 1.—Percentage of Number of Boards Varying from Average Thickness.

Observations in certain of the tests indicate that the gypsum does crack before the maximum load is reached and that the strength of the board therefore depends almost entirely upon the strength of the surfacing material. The modulus of rupture is the tensile strength which (as determined by calculation) the surfacing material would be required to have per inch of width in order to carry the maximum load if the gypsum between the layers of the material were to fail by cracking before the maximum load is reached. If this conclusion is correct, the modulus of rupture should be the same in the same direction for boards of varying thicknesses, provided the quality of the surface is the same. Due to the fact that the surfacing material of the different boards varies so much in strength and that the boards

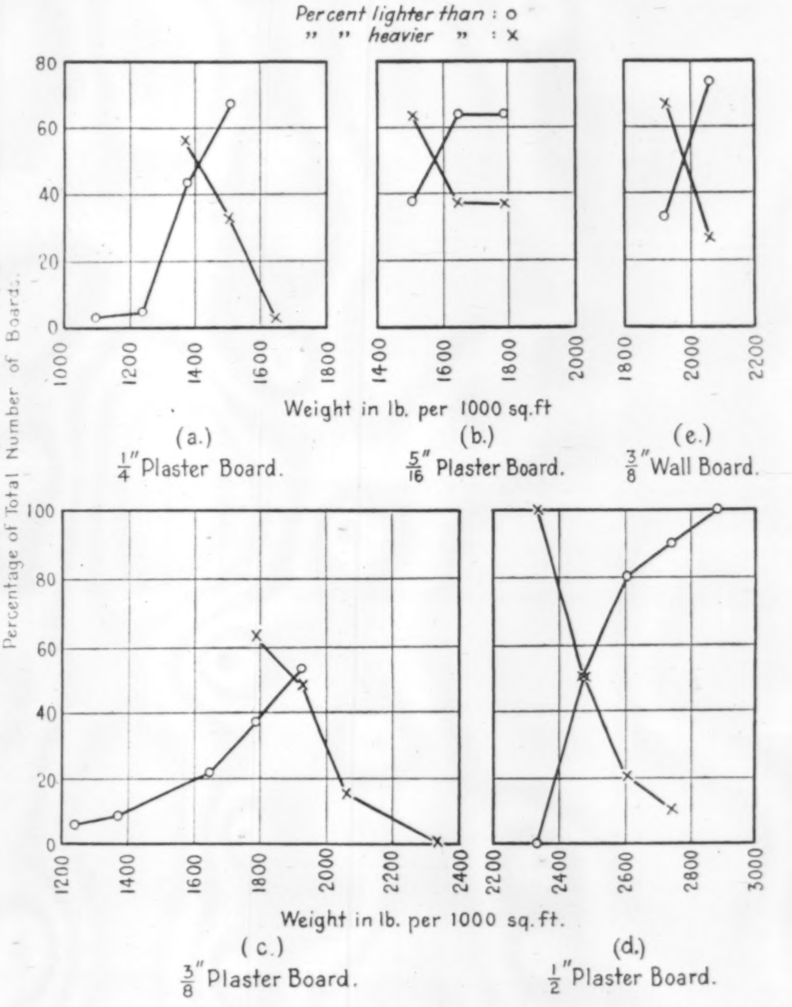

FIG. 2.—Percentage of Number of Boards Lighter Than or Heavier Than Weight Indicated.

TABLE I.—RESULTS OF PHYSICAL TESTS ON GYPSUM PLASTER AND WALL BOARDS.

Kind of Board.	Thickness, in.					Weight, lb. per 1000 sq. ft.			Strength Parallel with Fiber.						Strength Across Fiber.					
	Average.	Variation from Average.		Individual Variation from Average.					Breaking Load, lb.			Modulus of Rupture, lb. per linear inch.			Breaking Load, lb.			Modulus of Rupture, lb. per linear inch.		
		Maximum.	Average.	Maximum.	Average.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 p...	0.332	0.020	0.010	0.065	0.015	1 878	1 918	1 810	89.75	102.50	72.06	103.0	117.0	82.5	43.13	46.13	39.62	49.5	52.8	45.6
2 p...	0.311	0.023	0.010	0.116	0.109	1 198	1 322	1 080	62.38	74.88	55.00	76.4	91.7	67.4	29.19	36.56	25.31	35.75	44.8	31.0
3 p...	0.353	0.018	0.009	0.047	0.018	1 598	1 670	1 527	70.77	77.31	63.00	76.5	83.5	68.0	39.25	44.13	31.13	42.3	47.7	33.6
4 p...	0.407	0.041	0.020	0.188	0.039	2 188	2 270	1 955	87.25	93.00	79.19	81.7	87.4	47.0	39.94	44.69	35.00	37.4	41.8	32.8
5 p...	0.309	0.024	0.015	0.106	0.023	1 722	2 136	1 585	70.06	77.44	63.38	86.5	98.0	80.2	30.25	37.44	20.50	37.3	46.2	25.2
6 p...	0.340	0.015	0.006	0.065	0.015	1 862	1 975	1 530	61.00	76.63	48.69	68.4	85.8	54.5	38.00	40.13	34.00	42.5	44.8	38.1
7 p...	0.338	0.028	0.010	0.062	0.011	1 772	1 835	1 666	74.68	79.06	69.75	84.2	89.1	73.5	31.13	34.50	22.88	35.1	38.9	25.8
8 p...	0.324	0.020	0.009	0.072	0.019	1 607	1 644	1 588	36.36	39.50	30.88	42.8	46.5	63.4	22.32	24.13	19.13	26.2	28.4	22.5
9 p...	0.328	0.025	0.007	0.060	0.030	1 919	1 980	1 720	85.13	104.44	62.00	98.7	121.1	72.0	41.33	47.06	38.75	50.3	54.6	45.0
10 p...	0.314	0.023	0.008	0.066	0.014	1 337	1 395	1 173	71.43	78.19	57.62	86.7	92.4	70.0	39.54	42.62	37.06	47.9	51.7	45.0
11 p...	0.380	0.019	0.008	0.043	0.012	2 090	2 205	1 990	62.57	70.00	54.94	62.7	70.2	55.1	33.69	38.13	31.44	33.8	38.2	31.5
12 p...	0.350	0.015	0.010	0.016	0.006	1 854	1 945	1 763	70.70	85.75	60.56	77.0	93.3	66.0	43.43	45.00	34.50	47.2	49.0	37.5
13 p...	0.374	0.006	0.003	0.028	0.007	1 927	1 980	1 855	46.72	50.00	42.56	47.6	50.7	43.2	32.05	33.56	28.81	32.7	34.1	29.3
14 p...	0.336	0.010	0.005	0.033	0.008	1 955	2 020	1 890	54.63	58.00	52.19	62.0	65.7	59.2	32.66	36.50	26.81	37.0	41.3	30.4
15 p...	0.324	0.023	0.008	0.028	0.009	1 672	1 737	1 580	66.35	73.00	53.69	67.8	85.8	63.2	34.84	45.43	30.31	41.0	53.5	35.6
16 p...	0.263	0.017	0.011	0.026	0.007	1 473	1 497	1 460	60.62	62.13	59.13	87.8	90.0	85.8	30.00	31.50	28.25	43.5	45.7	41.0
17 p...	0.270	0.022	0.006	0.037	0.011	1 523	1 626	1 217	57.72	64.75	50.38	81.5	91.3	71.0	34.11	36.62	32.25	47.0	51.6	45.5
18 p...	0.264	0.010	0.005	0.042	0.019	1 236	1 280	1 210	46.54	57.50	25.00	67.2	83.0	66.0	28.34	32.44	24.00	40.8	47.0	34.6
19 p...	0.277	0.005	0.003	0.038	0.012	1 459	1 475	1 436	50.19	55.38	45.19	68.8	76.0	62.0	27.66	29.13	21.06	38.0	40.1	29.0
20 p...	0.251	0.009	0.003	0.028	0.009	1 249	1 277	1 220	33.32	36.50	26.62	50.6	55.5	40.3	19.95	22.88	18.56	30.3	34.8	28.1
21 p...	0.269	0.008	0.005	0.032	0.015	1 453	1 497	1 417	39.35	45.00	32.00	55.5	63.5	45.2	27.35	30.81	23.13	38.7	43.7	32.7
22 p...	0.250	0.014	0.007	0.026	0.008	1 207	1 387	1 018	49.92	54.06	41.88	74.5	82.5	63.8	26.16	28.00	21.88	39.8	42.7	35.4
23 p...	0.347	0.025	0.011	0.165	0.029	1 708	1 840	1 525	52.75	64.13	44.38	58.0	70.3	48.8	33.54	36.88	27.19	36.8	40.5	29.8
24 p...	0.265	0.014	0.005	0.019	0.007	1 426	1 503	1 400	54.10	62.88	47.50	77.8	90.4	68.3	28.10	30.50	23.69	40.3	43.8	34.1
25 p...	0.470	0.022	0.009	0.037	0.015	2 424	2 715	2 275	115.90	145.44	105.62	94.0	117.7	85.5	64.79	76.00	54.13	52.5	61.5	43.8
26 w...	0.401	0.003	0.002	0.044	0.011	2 052	2 090	2 015	102.33	107.31	98.13	97.3	102.0	93.3	45.82	49.13	41.00	43.6	46.8	39.0
27 w...	0.405	0.015	0.009	0.046	0.017	2 075	2 085	2 050	91.60	94.94	86.56	86.2	89.3	81.4	39.17	44.69	36.50	36.8	42.0	34.3
28 w...	0.385	0.010	0.005	0.021	0.006	1 922	1 945	1 910	87.34	90.19	86.25	85.5	89.2	85.3	40.14	41.44	38.94	39.7	41.0	38.5
29 w...	0.328	0.020	0.019	0.022	0.009	1 885	1 930	1 850	86.14	89.19	82.44	100.0	103.2	95.8	38.60	40.00	36.50	44.8	46.5	42.5
30 w...	0.364	0.002	0.001	0.020	0.006	2 059	2 080	2 040	95.19	100.00	91.75	99.6	104.6	96.0	43.45	46.19	39.50	45.4	48.3	41.3
31 w...	0.353	0.009	0.006	0.026	0.007	2 063	2 150	1 990	96.99	114.38	85.00	104.2	123.2	92.0	47.46	50.62	45.62	51.2	54.6	49.2

p = plaster boards.
w = wall boards

themselves vary as the surfaces, we readily see that we could not expect the modulus of rupture to be any more constant than the surfaces.

The results of the tests are best shown graphically. If we plot the percentages of the number of boards as ordinates and the weight or thickness of boards as abcissas we will have curves which very clearly show the number of boards which will come within and which will be eliminated by the Tentative Specifications for Gypsum Wall Board (C 36 – 22 T), and for Gypsum Plaster Board (C 37 – 22 T).[1]

Fig. 1(*a*) shows that there is very little variation in the thickness of the $\frac{1}{4}$-in. plaster boards. Fig. 2(*a*) shows the proportion of $\frac{1}{4}$-in. boards that have been found to come within the specifications in respect to weight. Figs. 1(*c*) and 2(*c*) show the same for $\frac{3}{8}$-in. plaster board, Figs. 1(*b*) and 2(*b*) for $\frac{5}{16}$-in. plaster board, and Figs. 1(*d*) and 2(*d*) show the variation of $\frac{1}{2}$-in. plaster board.

Figs. 1(*e*) and 2(*e*) show the variation of thickness and weight, respectively, of $\frac{3}{8}$-in. wall board.

In Table I, all of the results of the many tests have been summarized into as few figures as deemed necessary. Column No. 1 does not refer to a single board but each number indicates a series of similar boards from the same manufacturer. Column No. 2 is the average thickness of all the boards in the series, using five points on each board at which its thickness was measured. Columns No. 3 and 4 are the maximum and average variation from the average thickness. Columns Nos. 5 and 6 give the maximum and average variation of an individual board from the average thickness of that board. For Columns Nos. 5 and 6 the board was selected which showed the largest variations in thickness at different parts of the board. The meaning of the rest of the table is obvious from the headings.

The results of these tests may be used as a guide in suggesting revisions of the tentative specifications. It is evident that the multiply board, as far as the specifications cover, has no special advantages; in fact, the tests brought out the result that the three weakest boards were multi-ply. But the manufacturers of these boards do not claim more strength than that sufficient for a plaster board, but its other advantages that they do claim, such as toughness, giving a better nail hold, and a better board acoustically, could not be brought out in the scope of the investigation.

Acknowledgment is made for the valuable assistance given by Mr. W. E. Emley and Mr. W. A. Slater of the U. S. Bureau of Standards.

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[1] See pp. 710 and 712.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

Committee D-1 on Preservative Coatings for Structural Materials has held two meetings during the past year. At the first meeting, held in Philadelphia on October 4, 1921, twenty-five members were present. Reports were received from most of the standing sub-committees and plans for future work discussed. On April 4, 1922, the second meeting of the committee was held in Philadelphia, there being present thirty-three members, while excuses were received from thirty-two others. The committee now has 133 members, a gain of five members within the past year.

The committee, largely through its sub-committees, has been very active in various lines of work in regard to protective coatings, as a result of which a number of revisions in present standards and tentative standards have been made, and a number of new tentative standards have been proposed.

Since the last annual meeting, one new sub-committee has been appointed and is designated Sub-Committee XXIV on Testing of Paints on Various Kinds of Ferrous Metal. The members of Sub-Committee XXIV are to act with members appointed by Committee A-5 on Corrosion of Iron and Steel as a joint committee to test painting on various kinds of ferrous metal.

Sub-Committee III on Testing of Paint Vehicles has done some good work on the analysis of chia oil, rubberseed oil, sunflower-seed oil and tung oil. The work of this sub-committee has resulted in proposed Tentative Specifications for Soya Bean Oil and for Perilla Oil, and a further revision of the present Standard Specifications for Purity of Raw Tung Oil (D 12 – 16).

Sub-Committee VIII on Methods of Analysis of Paint Materials has submitted proposed Tentative Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments, and Chrome Green.

Sub-Committee IX on Varnish has done a large amount of excellent work on tests to determine varnish characteristics.

Sub-Committee XXII on Method of the Application of Paint by Spraying has done a large amount of work and has conducted extensive tests in comparing the application of paint with brushes and with paint spraying machines on four buildings at Bridgeville, Pa. The sub-committee also prepared a very interesting moving picture film showing the manner in which the tests were carried out.

Sub-Committee XXIII on Anti-Fouling Paints has carried on a series of tests with various ship-bottom paints. These tests were made by exposing various ship-bottom paints, containing different toxic materials, on steel panels in Raritan Bay, Perth Amboy, N. J., and in the bay at Charleston, S. C.

Sub-Committee XXIV, the joint committee with Committee A-5, on Testing of Paints on Various Kinds of Ferrous Metal, has considered testing of different paints on various kinds of ferrous metal. The joint committee has outlined tests with three typical ferrous metal paints on pure iron, steel containing copper, and steel free from copper.

Details of the work of the sub-committees are contained in the full sub-committee reports which are a part of this report.

This report has been submitted to letter ballot of the committee, which consists of 133 members from whom 39 replies were received. The vote was taken on each section of the report with the following results:

	FOR.	AGAINST.	NOT VOTING.
General Report	39	0	0
Report of Sub-Committee III on Testing of Paint Vehicles, including tentative revisions of the Standard Specifications for Purity of Raw Tung Oil (D 12 – 16)	32	0	7
Tentative Specifications for Soya Bean Oil, Raw or Refined	32	0	7
Tentative Specifications for Perilla Oil, Raw or Refined	31	0	8
Report of Sub-Committee VI on Definitions of Terms Used in Paint Specifications, including revision and advancement to standard of the Tentative Definitions:			
Size	32	0	7
Varnish	33	0	6
Enamel	33	0	6
Filler	33	0	6
Toner	32	0	7
Lake	32	0	7
Drying Oil	33	0	6
Semi-Drying Oil	33	0	6
Non-Drying Oil	33	0	6

	FOR.	AGAINST.	NOT VOTING.
Report of Sub-Committee VIII on Methods of Analysis of Paint Materials, including Tentative Methods of Analysis of:			
Yellow and Orange Pigment containing Chromium Compounds	34	0	5
Blue Pigments	34	0	5
Chrome Green	34	0	5
Report of Sub-Committee IX on Varnish	30	0	9
Report of Sub-Committee XIV on Preparation of Iron and Steel Surfaces for Painting	33	0	6
Report of Sub-Committee XXI on Specifications for the Fundamental Requirements of Paint for Specific Purposes	30	0	9
Report of Sub-Committee XXII on Method of the Application of Paint by Spraying	35	0	4
Report of Sub-Committee XXIII on Anti-Fouling Paints	36	0	3

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

R. L. HALLETT,
Secretary.

EDITORIAL NOTE.

The Tentative Definitions of Terms Relating to Paint Specifications amended as indicated in this report were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1922.

The proposed revisions of the Standard Specifications for Purity of Raw Tung Oil referred to in this report were accepted as new tentative specifications and appear on page 742.

The proposed Tentative Specifications for Soya Bean Oil, Raw or Refined, the proposed Tentative Specifications for Perilla Oil, Raw or Refined, and the proposed Tentative Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green were accepted for publication as tentative and appear on pages 748–765.

REPORT OF SUB-COMMITTEE III ON TESTING OF PAINT VEHICLES.

During the past year the members of the sub-committee have done cooperative work on the analysis of samples of chia oil, rubberseed oil, sunflower-seed oil, and tung oil.

The chia oil used was pressed at the Institute of Paint and Varnish Research from a ton lot of chia seed imported by the Educational Bureau of the Paint Manufacturers' Association, direct from Mexico. The seed was identified by the U. S. Department of Agriculture. (See *Circular No. 105*, Educational Bureau, Paint Manufacturers' Association of the U. S.)

The rubberseed oil was obtained at the suggestion of the Imperial Institute, of London, through the courtesy of the Produce Brokers Co., London, and MacAndrews, Moreland Co., Liverpool. (See *Circular No. 118*, Educational Bureau, Paint Manufacturers' Association of the U. S.)

The unrefined sunflower-seed oil was obtained from the American Cotton Oil Co., being pressed by them from a crop of Missouri sunflower seeds. The refined sunflower-seed oil was from a sample obtained from the U. S. Department of Agriculture three years ago. (See *Circular No. 136*, Educational Bureau, Paint Manufacturers' Association of the U. S.)

The imported tung oil No. 2 was imported from China, being a sample of the 1920 crop, obtained under careful supervision of an importer's agent in the Wanshien District. (See *Circular No. 119*, Educational Bureau, Paint Manufacturers' Association of the U. S.)

The American tung oil was expressed from a batch of American grown tung-oil nuts collected in Florida by the chairman of the subcommittee.

In forwarding the oils, it was stated that they should be examined in accordance with the methods outlined in *Circular No. 82* of the Bureau of Standards for the analysis of linseed oil. It would appear that these methods in use by different operators in widely distributed laboratories should give closely agreeing results.

For the examination of the sample of tung oil, it was requested that the determination of the iodine number should be made with both the Wijs solution and with the Hübl solution. It was considered desirable to determine whether the Wijs solution could be used, in view of the very much shorter period of time required for this test. The Hübl method to be followed appears in the present published Standard Specifications for Purity of Raw Tung Oil (Serial Designation: D 12 – 16) of the American Society for Testing Materials.[1] The following outline for the Wijs method was transmitted to the members.

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[1] 1921 Book of A.S.T.M. Standards.

WIJS IODINE NUMBER.

Solutions Required.—The solutions required are one of iodine monochloride containing 13 g. of iodine per liter, in glacial acetic acid that has a melting point of 14.7 to 15° C. and is free from reducing impurities; and another of sodium thiosulfate, made by dissolving 24.83 g. of the pure salt in a liter of water. In addition to these solutions there is required a quantity of acetic acid of the same strength as that used for making the solution of iodine monochloride. Pure chloroform and starch are also necessary.

The preparation of the iodine-monochloride solution presents no great difficulty, but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine, over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. Set aside a small portion of this solution, while pure, and pass dry chlorine into the remainder until the halogen content of the whole solution is doubled. Ordinarily it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine, which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided.

Method.—Place a small quantity of the sample in a small weighing burette or beaker. Weigh accurately. Transfer by dropping from 0.16 to 0.19 g. to a 500-cc. bottle having a well-ground glass stopper, or an Erlenmeyer flask having a specially flanged neck for the iodine tests. Reweigh the burette or beaker and determine the amount of sample used. Add 10 cc. of chloroform. Whirl the bottle to dissolve the sample. Add 10 cc. of chloroform to each of two empty bottles like that used for the sample. Add to each bottle 25 cc. of the Wijs solution and let stand with occasional shaking for one-half hour in a dark place at a temperature of from 21 to 23° C. Add 10 cc. of a 15-per-cent potassium iodide solution and 100 cc. of water, and titrate with standard sodium thiosulfate using starch as the indicator. The titrations on the two blank tests should agree within 0.1 cc. From the difference between the average of the blank titration and the titration on the samples and the iodine value of the thiosulfate solution, calculate the iodine number of the samples tested. (Iodine number is given in centigrams of iodine to 1 g. of sample.)

As a result of some early investigations conducted during the year 1919 by the Bureau of Standards, considerable information is available regarding the comparative value of the two iodine methods: namely, Wijs and Hübl, when used upon Chinese wood oil (tung oil). There are given below the results on a sample of pure tung oil expressed from Chinese nuts by Sub-Committee III. (See *Proceedings*, Am. Soc. Test. Mats., Vol. XIV, Part I, p. 237 (1914).) The average iodine number on this oil, as reported to the committee by ten analysts, using the Hübl method (18 hours) was 169.6. The sample had been preserved in a full black bottle.

TABLE I.—RESULTS OF COOPERATIVE ANALYSIS ON SAMPLES OF CHIA OIL RUBBERSEED OIL, SUNFLOWER-SEED OIL AND TUNG OIL.

	Specific Gravity, 15.5°/15.5°C.	Acid Value.	Saponification Number.	Iodine Number.			Heat Test.			
				Hanus.	Wijs.	Hübl.	Original Oil.		Zero Acidity after Lime Treatment.	
							Min.	Sec.	Min.	Sec.
CHIA OIL.										
Gardner and Reilly	0.9342	0.3	191.6	194.6	199.9	.....	..	..	..	..
Steele, Came and Sward	0.9340	0.25	193.1	196.2	200.8	.....	..	..	..	..
R. W. Lindsay	0.9344	0.4	193.3	195.2	198.6	.....	..	..	..	..
Fasig, Marling and Howell	0.9345	0.4	192.0	196.6	202.1	.....	..	..	..	..
White and Crowley	0.9344	0.4	192.1	196.5	199.5	.....	..	..	..	..
J. H. Calbeck	0.9340	0.35	192.3	194.5	200.7	.....	..	..	..	..
Average	0.9343	0.35	192.4	195.4	200.4					
RUBBERSEED OIL.										
Gardner and Reilly	0.9249	58.8	195.1	136.7	137.8	.....	..	..	..	..
Steele, Came and Sward	0.9247	59.2	192.6	136.9	138.4	.....	..	..	..	..
R. W. Lindsay	0.9242	56.9	194.5	137.2	137.8	.....	..	..	..	..
Fasig, Marling and Howell	0.9255	60.0	190.6	134.9	141.6	.....	..	..	..	..
White and Crowley	0.9245	57.7	193.5	136.5	139.0	.....	..	..	..	..
J. H. Calbeck	0.9255	61.0	193.7	139.0	138.0	.....	..	..	..	..
Average	0.9249	58.9	193.3	136.9	138.7					
SUNFLOWER-SEED OIL (UNREFINED).										
Gardner and Reilly	0.9245	2.2	191.1	128.1	130.0	.....	..	..	..	..
Steele, Came and Sward	0.9239	2.2	189.7	128.6	130.8	.....	..	..	..	..
R. W. Lindsay	0.9235	2.1	193.0	127.6	129.5	.....	..	..	..	..
Fasig, Marling and Howell	0.9255	2.4	192.7	129.4	131.8	.....	..	..	..	..
White and Crowley	0.9254	2.1	.....	126.0	129.0	.....	..	..	..	..
J. H. Calbeck	0.9251	2.19	191.9	131.5	130.7	.....	..	..	..	..
Average	0.9246	2.20	191.7	128.5	130.3					
SUNFLOWER-SEED OIL (U. S. DEPT. AGRICULTURE).										
Gardner and Reilly	0.9237	5.4	192.0	119.0	120.7	.....	..	..	..	..
Steele, Came and Sward	0.9235	5.4	192.3	119.7	121.4	.....	..	..	..	..
R. W. Lindsay	0.9234	5.2	193.2	119.0	120.4	.....	..	..	..	..
Fasig, Marling and Howell	0.9255	5.2	189.2	120.9	124.8	.....	..	..	..	..
White and Crowley	0.9242	5.5	.....	117.5	120.0	.....	..	..	..	..
J. H. Calbeck	0.9241	5.7	192.0	122.1	121.5	.....	..	..	..	..
Average	0.9241	5.4	191.7	119.7	121.5					
TUNG OIL (IMPORTED.)										
Gardner and Reilly	0.9423	4.4	194.9	.....	165.6	172.5	11	..	9	40
Steele, Came and Sward	0.9417	4.3 (4.8)[a]	192.7	.....	168.8	.....	10	50	9	30
R. W. Lindsay	0.9417	3.9	196.7	.....	166.5	168.7	11	45	..	..
Fasig, Marling and Howell	0.9412	4.4	194.0	.....	170.0	.....	11	10	..	..
White and Crowley	0.9425	4.4	194.0	.....	.....	171.5	12	..	..	..
J. H. Calbeck	0.9423	4.9	193.7	.....	170.2	169.0	..	..	..	..
Average	0.9420	4.4	194.4		168.2	170.4	11	21	9	35
TUNG OIL (AMERICAN).										
Gardner and Reilly	0.9411	0.15	194.6	.....	166.4	171.8	10	50	10	25
Steele, Came and Sward	......	0.10 (0.15)[a]	194.1	.....	166.4	.....	10	30	9	50
Fasig, Marling and Howell	0.942	0.4	.....	.....	168.2	.....	11	20	..	..
White and Crowley	0.9416	0.2	192.0	.....	.....	170.0	8	45	..	..
J. H. Calbeck	0.9407	0.9	192.2	.....	171.8	167.4	..	..	..	..
Average	0.9414	0.35	193.2		168.2	169.7	10	40	10	8
JAPAN TUNG OIL.										
Gardner and Reilly	0.9342	0.9	193.2	.....	150.2	154.4	Negative		Negative	
SUNFLOWER-SEED OIL (S. M. C. S. G. A.).										
Gardner and Reilly	0.9246	2.3	190.1	128.5	131.5	.....	..	..	..	..

[a] Alcohol-Benzol Method.

Iodine Numbers of Pure Tung Oil.

Wijs Method.			Hübl Method.		
½ HR. 14–15° C.	1 HR. 20–21° C.	⅓ HR. 39–40° C.	18 HR. 11–16° C.	18 HR. 19–21° C.	18 HR. 37–44° C.
164.5	166.8	169.7	169.4	169.8	148.6
164.5	165.5	170.1	169.9	168.5	148.6

It will be noted that the results with tung oil by the Wijs method at the lower temperatures are lower than by the Hübl method. It is only at unusually high temperatures that the Wijs number is greater than the Hübl number at such temperatures, but at these high temperatures the Hübl method apparently gives erroneous results.

In Table I the results are given of the analyses made during the past year by members of the sub-committee.

There are also included a number of comments on the work by various observers, together with a report of additional work by L. L. Steele.

Comments by Mr. E. W. Fasig.

The work was done by Mr. Marling and Mr. Howell of the laboratory. Owing to the fact that we have abandoned the use of ethyl alcohol in our laboratory, it was impossible to make the Hübl iodine determination on the two samples of tung oil.

The Wijs method used in this work was the same as the Hanus method described in *Circular No. 82* of the Bureau of Standards, except that the Wijs solution when acting upon the oil for one-half hour was kept in a dark place at a temperature around 21° C. The Wijs solution was made by passing chlorine into iodine-glacial acetic acid solution, in accordance with the method given in the Standard Methods of Testing Shellac (Serial Designation: D 29 – 17) of the American Society for Testing Materials.[1] The other reagents were made up according to the method Bureau of Standards *Circular No. 82*. The heating test was made in accordance with the method given in the tentative revision of the Standard Specifications for Purity of Raw Tung Oil (Serial Designation: D 12 – 16) of the American Society for Testing Materials.[2]

Comments by Mr. J. H. Calbeck.

All determinations were carried out as directed with one exception. The acetic acid used in determining the iodine value by the method of Wijs was not as recommended and we are planning to repeat these determinations and check up our other iodine values as soon as we can find time to continue the work.

All determinations recorded are the averages of four or five different determinations. We encountered no particular difficulty in any of the analyses, except in the method of Wijs.

Supplementary Report by L. L. Steele.

In accordance with the suggestions from the chairman, drying tests were made upon all of the samples of oil except the tung oil. A sample of pure raw linseed oil was run in parallel in the drying tests. A comparison of the siccative properties of the oils was made by incorporating various amounts of cobalt (in the form of cobalt resinate of known metal content) with the various samples and determining the relative lengths of time needed for drying on glass plates. The results are given in Table II.

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 835 (1921).

TABLE II.—DRYING EXPERIMENTS OF VARIOUS OILS WITH COBALT.

	Length of Time to Slightly Set.		Length of Time to Set.		Length of Time to Nearly Dry.		Length of Time to Dry.
	Hr.	Min.	Hr.	Min.	Hr.	Min.	
Refined Sunflower-Seed Oil with 0.32 per cent Co..	1	35	2	30	.	..	Not dry after 2 days
" " " " 0.17 per cent Co..	2	30	3	15	.	..	Not dry after 2 days
" " " " 0.09 per cent Co..	3	45	4	15	.	..	Not dry after 2 days
Unrefined Sunflower-Seed Oil with 0.29 per cent Co.	.	..	1	45	2	30	Not dry after 2 days.
" " " " 0.14 per cent Co.	2	15	2	30	2	45	Not dry after 2 days.
" " " " 0.09 per cent Co.	2	45	.	..	3	15	Not dry after 2 days.
Chia Oil with 0.29 per cent Co.	.	..	.	45	.	..	1 hr. 15 min.
" " " 0.18 per cent Co.	.	..	1	..	.	..	1 hr. 15 min.
" " " 0.09 per cent Co.	1	..	1	15	1	25	1 hr. 35 min.
Rubberseed Oil with 0.26 per cent Co.	1	15	3	15	.	..	Not dry after 2 days.
" " " 0.16 per cent Co.	2	45	4	15	.	..	Not dry after 2 days.
" " " 0.10 per cent Co.	2	45	4	15	.	..	Not dry after 2 days.
Raw Linseed Oil with 0.30 per cent Co.	.	..	1	25	1	35	1 hr. 45 min.
" " " " 0.15 per cent Co.	1	25	1	35	.	..	2 hr. 45 min.
" " " " 0.09 per cent Co.	2	45	3	15	3	45	4 hr. 15 min.

The four samples of oil were mixed with a commercial sample of liquid paint drier in the proportion of one part drier by volume to nine parts of oil, and the drying properties of the mixtures determined as follows:

DRYING EXPERIMENTS OF VARIOUS OILS WITH LIQUID DRIER.

	Refined Sunflower-Seed Oil.	Unrefined Sunflower-Seed Oil.	Chia Oil.	Rubberseed Oil.
Length of time to slightly set.	....	....	1 hr. 45 min.	....
Length of time to set........	....	....	2 hr. 15 min.	....
Length of time to nearly dry..	About 24 hr.	About 24 hr.	2 hr. 30 min.	About 24 hr.
Length of time to dry.......	Not dry after 2 days.	Not dry after 2 days.	2 hr. 45 min.	Not dry after 2 days.

The terms "slightly set", "set", "nearly dry" and "dry" which have been used may be defined as follows: The oil was "slightly set" when it first showed signs of losing its "greasy" feel. The oil was "set" when it felt tacky to the finger. The oil was "nearly dry" when the oil no longer adhered to the finger when lightly touched but the film was abraded when the finger was drawn lightly across its surface. The film was "dry" when it did not become abraded when the finger was drawn lightly across it's surface and when the film was firm under gentle pressure of the finger.

Portions of the four samples of oil were heated to 250° C. in glass beakers and a rapid current of air passed through them by means of a glass tube. After 6 hours of this treatment, the chia oil was practically unchanged in color and was somewhat "bodied". After 5½ hours of this treatment, the rubberseed oil became very thick and darker in color than the original sample. After 6 hours of this treatment, both the refined and unrefined samples of sunflower-seed oil were slightly "bodied" and showed a considerable "break" or deposit of foots.

The drying experiments indicated that chia oil dried somewhat faster than linseed oil under the same conditions and with the same content of drier. In none of the experiments, using cobalt and liquid paint drier, did a film of rubberseed, refined sunflower-seed or unrefined sunflower-seed oil dry to a firm satisfactory film on glass.

The high iodine value for chia oil, together with its rapid drying properties are suggestive of perilla oil. The hexabromide yield of the fatty acids of a sample of chia oil by the Steele-Washburn Method was found to average 50.4 per cent. This value is very close to the hexabromide yield by the same method for the fatty acids of two samples of perilla oil (believed to be authentic) of 48.0 and 50.0 per cent, respectively.

The analytical work on the above oils was partly done by Dr. L. L. Steele personally and partly by Messrs. C. L. Came and G. G. Sward under his direct supervision.

Conclusion.—It would appear from the results obtained by the various observers that the Wijs method, if conducted with the carefully standardized Wijs solution referred to, will give accurate results on tung oil. It would also appear that the results correspond closely with those obtained with the Hübl solution, being on the average two points lower. In this connection, it is interesting to record the fact that the Fat Analysis Committee of the American Chemical Society has done considerable work on the determination of the iodine number of tung oil with both Wijs and Hübl solutions. The work of this committee substantiates their findings. In view of this, it is recommended that in the Standard Specifications for Purity of Raw Tung Oil (D 12–16)[1] the iodine number (Wijs) be used in place of the iodine number (Hübl). In place, however, of a minimum of 165 Hübl, a minimum of 163 Wijs is recommended.

It is also recommended that the lime treatment of the oil before the heat test be omitted. In the heating test on tung oil, the oil requiring the lowest number of minutes to become firmly set is considered the most satisfactory for use. With increase in acidity, increase in time of setting is always shown. Oils that fall within the limits for acidity prescribed in the specifications should never require more than 12 minutes to firmly set. A shorter period would indicate a superior oil. Oils that are high in acidity and setting time in the heat test, may when neutralized by shaking with hydrated lime and filtered, show firm setting when heated for a period of from 9 to 10 minutes. Such a result would indicate purity of the oil but would not indicate its value for use in the varnish industry. The lime test[1] is, however, of value to apply when adulteration with other oils is suspected. Methods for determination of Specific Gravity, Acid Number, Saponification Number, and Unsaponifiable Matter are rewritten to correspond with the methods for determining these properties as applied to other oils.[2]

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[1] 1921 Book of A.S.T.M. Standards.

There are also appended to this report tentative specifications for soya and perilla oils.[3] These specifications were originally submitted to the members of the sub-committee in suggested form (see *Circular No. 137*, Educational Bureau, Paint Manufacturers' Association of the U. S.). The various members of the committee, after giving them careful consideration and checking up the results obtained on several hundred deliveries of commercial soya and perilla oil, have suggested changes which have been embodied in the specifications. It is recommended that these be accepted as tentative standards.

Respectfully submitted on behalf of the sub-committee.

HENRY A. GARDNER,
Chairman.

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[1] Tentative Revision of the Standard Specifications for Purity of Raw Tung Oil (Serial Designation: D 12-16), *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 835 (1921).

[2] The several revisions recommended above have been embodied in new Tentative Specifications for Raw Tung Oil to supersede when adopted the present Standard Specifications for Purity of Raw Tung Oil (Serial Designation: D 12-16). For these Tentative Specifications, see p. 742.—ED.

[3] See pp. 748-753.—ED.

REPORT OF SUB-COMMITTEE VI ON DEFINITIONS OF TERMS USED IN PAINT SPECIFICATIONS.

Committee E-8 on Nomenclature and Definitions reviewed and suggested certain changes in the Tentative Definitions of Terms Relating to Paint Specifications (D 16 – 21 T).[1]

These suggested changes which for the most part were in form only have been approved and the tentative definitions re-written as appended hereto. Sub-Committee VI recommends that the tentative definitions as revised in accordance with these suggestions be advanced to standard.

Respectfully submitted on behalf of the sub-committee,

L. P. Nemzek,
Chairman.

REPORT OF SUB-COMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS.

Methods compiled from the literature are submitted herewith as proposed Tentative Methods of Routine Analysis of Yellow and Orange Pigments containing Chromium Compounds, Blue Pigments, and Chrome Green,[2] with the recommendation that they be accepted for publication as tentative.

Respectfully submitted on behalf of the sub-committee,

F. W. Smither,
Chairman.

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[1] *Proceedings* Am. Soc. Test. Mats., Vol. 21, p. 629 (1921).

[2] See p. 754.—Ed.

REPORT OF SUB-COMMITTEE IX ON VARNISH.

Sub-Committee IX is at present composed of twenty-six members.

The work of the past year has consisted of investigating the accuracy and value of various physical tests which could comprise standard methods of testing varnishes. A number of the tests under examination are now included in the specifications recommended by the Inter-Departmental Committee on Paint Specification Standardization of the United States.

Four varnishes were prepared for this purpose, and two 8-oz. cans of each were sent to twenty-one members who had reported they could undertake the work. These samples were marked *A*, *B*, *C* and *D*. Their composition and manufacture are known and will be published when the tests have been completed.

A sample of "Run Kauri" (prepared in accordance with the directions herewith, for the use of the Pittsburgh Laboratory of the Signal Corps during the War) and a sample of standard tin plate were furnished each operator. He was requested to run the Kauri Reduction test with both the standard gum and with a sample of gum prepared in his own laboratory.

Details of the methods under investigation are as follows:

METHODS OF TESTING VARNISHES PROPOSED FOR INVESTIGATION BY SUB-COMMITTEE IX.

General.—All tests will be made at a room temperature between 21 and 32° C. (70 and 90° F.).

All tests will be made in diffused light (not in direct sunlight).

The tin panels used shall be cut from bright tin plate weighing not more than 25 g. nor less than 19 g. per square decimeter (0.51 to 0.39 lb. per sq. ft. Commercial No. 31 gage bright tin plate should weigh about 0.44 lb. per sq. ft. It is important that the tin plate used shall be within the limits set. The panels shall be about 7.5 by 13 cm. (3 by 5 in.) and must be thoroughly cleaned with benzol immediately before using. (Be sure rags used in wiping are clean.)

When a can is opened and part of it is used, immediately place what is left in containers which the varnish entirely fills, leaving not more than 2 per cent of air space. Such containers should be absolutely air tight.

Appearance.—Pour some of the thoroughly mixed sample into a clear glass bottle or test tube and examine by transmitted light. The varnish must be clear and transparent. The tubes used for this test shall be 1.5 to 2.0 cm. ($\frac{5}{8}$ to $\frac{13}{16}$ in.) in diameter and shall be filled to a depth of at least 2.5 cm.

Color.—Prepare standard color solutions by dissolving 1, 2, 3, 4, 5, and 6 g., respectively, of pure powdered potassium dichromate in 100 cc. of pure concentrated H_2SO_4 (sp. gr. 1.84). Gentle heat may be used if necessary to perfect the solution of the dichromate. The standard color solutions and a sample of the varnish to be tested shall be placed in clear thin-walled glass tubes of the same diameter. The color comparison shall be made by placing the tubes close together and looking through them by transmitted light. The tubes used for this test should be 1.5 to 2.0 cm. ($\frac{5}{8}$ to $\frac{13}{16}$ in.) in diameter and shall be filled to a depth of at least 2.5 cm. (1 in.). Since the potassium dichromate-sulfuric acid must be freshly made for this color comparison, it is frequently more convenient to compare samples with a permanently sealed tube of varnish which has previously been found to be slightly lighter in color than the standard solution. When samples are found to be darker than this standard tube of varnish, the dichromate standard should be made up for final decision. State color as that of the standard (calling the standards No. 1, No. 2, No. 3, etc.) with which it is equal or lighter than.

Non-Volatile Matter.—Place a portion of the sample in a stoppered bottle or weighing pipette. Weigh the container and sample. Transfer about 1.5 g. of the sample to be weighed to a flat-bottomed metal dish about 8 cm. in diameter (a friction-top can plug). Weigh the container again and by difference calculate the exact weight of the portion of sample transferred to the weighed dish. Heat the dish and contents in an oven maintained at 105 to 110° C. (221 to 230° F.) for three hours. Cool and weigh. From the weight of the residue left in the dish and the weight of the sample taken, calculate the percentage of non-volatile residue.

Drying Time.—Pour the varnish on one of the tin panels described above covering the panel. Place the panel in a nearly vertical position in a well-ventilated room but not in the direct rays of the sun. The atmosphere of this room must be free from products of combustion or laboratory fumes. The temperature of the room should be from 21 to 32° C. (70 to 90° F.). The film is tested at points not less than 2.5 cm. (1 in.) from the edges of the film by touching lightly with the finger. The varnish is considered to be "dry to touch" when gentle pressure of the finger shows a tacky condition but none of the varnish adheres to the finger. The varnish is considered to have "dried hard" when the pressure that can be exerted between the thumb and finger does not move the film or leave a mark which remains noticeable after the spot is lightly polished. If possible, record the average temperature and relative humidity during this determination and state the results in hours and minutes under time of drying to touch, testing every 15 minutes. Under drying hard, state the varnish to have dried hard or not to have dried hard in 24 hours.

Water Resistance.—Pour the varnish on one of the standard tin panels. Allow to dry for 48 hours. Place one of these panels in a beaker containing about 2.5 in. of distilled water at room temperature (immersing the end of the panel which was uppermost during the drying period) and leave in water for 18 hours. Report whether the varnish has turned white or any other observations. Wipe off all water. Allow to dry for 2 hours and report condition. Determine whether the films are softened immediately on removal from the water and two hours after removal.

Hot Water Test.—Prepare the panels as for cold water test. After drying for 48 hours, place in a beaker containing 2.5 in. of boiling distilled water (immersing the end of the panel which was uppermost during the drying period). Allow to remain for fifteen minutes. Observe the condition on removal from the water and also two hours after removal.

Place a second panel (prepared and dried in the same manner) in another beaker of boiling distilled water for 15 minutes. Then cool quickly to room temperature by adding cold water. Remove the panel and report the condition then and two hours after removal.

Elasticity.—The elasticity of the varnish is determined by the Kauri Reduction test as follows: By proportionately reducing its elasticity by the addition of a standard solution of "Run Kauri gum" in pure spirits of turpentine.

(1) *Preparation of the "Run Kauri":*

Arrange a distillation flask, water-cooled condenser and a tared receiver on a balance. Place in the flask about one-third of its volumetric capacity of clear bright hard pieces of Kauri gum broken to pea size. Carefully melt and distill until 25 per cent by weight of the gum taken is collected in the tared receiver. (At the end of the distillation, the thermometer in the distillation flask with the bulb at the level of the discharging point of the flask should register about 316° C. (600° F.)). Pour the residue into a clean pan and when cold break up into small pieces.

(2) *Preparation of Standard "Run Kauri" Solution:*

Place a quantity of the small broken pieces of Run Kauri together with twice its weight of freshly re-distilled spirits of turpentine, using only that portion distilling over between 153 and 170° C. (308 and 338° F.). in a carefully tared beaker. Dissolve by heating to a temperature of about 149° C. (300° F.) and bring back to correct weight when cold by the addition of the amount of re-distilled spirits of turpentine necessary to replace the loss by evaporation during the dissolving of the gum.

(3) *Reduction of the Varnish:*

Having carefully determined the non-volatile content of the varnish according to the proposed standard method, take 100 parts by weight of the varnish and add to it an amount of the standard Run Kauri solution equivalent to 50 per cent by weight, of the non-volatile matter in the varnish. Mix the varnish and the solution thoroughly.

(4) Flow a coat of the varnish thus reduced on one of the tin panels described above and let stand in a nearly vertical position at room temperature for one hour. Next, place the panel in a horizontal position in a properly ventilated oven and bake for five hours at 95 to 100° C. Remove the panel from the oven and allow to cool at room temperature (preferably 24° C. (75° F.)) for one hour.

(5) *Bending the Panel:*

Place the panel with the varnished side uppermost over a 3-mm. (⅛-in.) rod, held firmly by suitable supports, at a point equi-distant from the top and bottom edges of the panel and bend the panel double rapidly. The varnish must show no cracking whatsoever at the point of bending. For accurate results the bending of the panel should always be done at 24° C. (75° F.) for a lowering of the temperature will lower the percentage of reduction that the varnish will stand without cracking while an increase in temperature increases the percentage of reduction that the varnish will stand.

Varnishes which do not show cracks under this test are said to pass a fifty-per-cent reduction, while those that do crack do not pass a fifty-per-cent reduction.

The varnishes which have not cracked should be tested again, changing the amount of reduction to sixty per cent, and, if they pass this amount of reduction reduce them to seventy per cent.

In a similar manner, test varnishes which have cracked at fifty per cent, using reductions of thirty and forty per cent.

In this way, we will have determined the limits within ten per cent at which a varnish passes one amount of reduction and does not pass the next.

For example, we will report the varnishes as passing forty per cent, and breaking at fifty per cent.

It is suggested that a 20-g. sample of varnish is sufficient for each reduction If the non-volatile content of the varnish should be 48.6 per cent, then add 4.86 g.

of Standard Kauri Gum solution to the 20 g. of varnish and a fifty-per-cent reduction will be obtained.

Durability by Exposure.—Durability tests are so much influenced by weather conditions that it is always necessary to make them in comparison to a standard of known durability and performance. Inasmuch as we have no such standard, our durability tests will amount to a comparison of these four varnishes with each other. The tests shall be made on unfilled panels of maple wood 4 by 12 by ½ in. Three coats of varnish shall be applied to each test panel allowing three days for drying of each coat.

The first coat, after drying indoors for three days, shall be lightly sand-papered with No. 00 sand-paper before applying the second coat. The second and third coats shall not be sand-papered or rubbed. The backs and edges of the panels shall be varnished with three coats of the samples but for these surfaces the details of the method of application as given need not be adhered to and the effects of exposure on these surfaces shall not be considered.

Three days after the application of the third coat, the panel shall be exposed outdoors 45 deg. to the vertical, facing south. The panel shall be inspected at intervals of one week. A varnish shall be considered to have failed when the first cracks appear.

A second exposure test shall be made in the following manner: Two of the standard tin plates shall be coated with each of the varnishes by flowing the varnish over the panel and drying standing in a nearly vertical position. After three days drying, each panel shall be given a second coat, allowing the varnish to drain in the opposite direction. This test will then be in duplicate. Six days after the last coat has been applied, place these panels on the roof. This will be the same time that the wooden panels are exposed out of doors. Inspect once every week and report the first cracks as evidence of failure, disregarding cracks appearing within ½ in. of the edge of the panel. These tin panels will also be exposed at any angle of 45 deg. to the vertical, facing south.

In reporting the results of this test, be careful to report the comparative durability on wood and on the tin panels and any remarks as to which method you consider the better.

There are also included a number of comments on the work:

REMARKS.

Appearance.—Inasmuch as varnish is not a true solution and is apparently not optically homogeneous, absolute clarity is not generally reached.

Color.—The method used seems to be well adapted for specification work.

Another interesting use of secondary standards for determining the color of varnish is that of the Gardner-Holt Color Standards. Here caramel water solutions preserved with sodium-benzoate are employed. The results obtained by several operators using these standards are as follows:

COLOR (GARDNER-HOLDT COLOR STANDARDS).

SAMPLE.	GARDNER.	INGALLS.	STOPPEL.	COLE.
A	4+	4+	4	4
B	10	10	10	10
C	7	7	7	7
D	5+	5+	5+	5+

Non-Volatile Matter.—The method here used gives concordant results in the hands of different operators. The reports, on all four varnishes, are within 1 per cent

TABLE I.—SUMMARY OF RESULTS OF VARNISH TESTS BY VARIOUS OPERATORS.

Operator.	Sample.	Appearance.	Color.	Non-Volatile Matter.	Drying.				Water Resistance (Cold Water).		Water Resistance (Hot Water).		Elasticity (Kauri Reduction Test).	
					Average Temperature, deg. Fahr.	Relative Humidity, per cent.	Drying to Touch, hr.	Drying Hard and Tough in 24 hr.	On Removal.	2 hrs. after Removal.	On Removal	2 hrs. after Removal.	Using Standard "Run Kaur	Using Own "Run" Kauri
F. G. Breyer	A	Clear	½	47.5	71 6	45	2	Yes	V. Sl. Affected	Unaffected	Sl. Affected	Unaffected	......	......
	B	Clear	6	53.0			5	Yes	Sl. Affected	Unaffected	Affected	Sl. Affected	......	......
	C	V. Sl. Cloudy	2	45.9			7½	Yes	Badly Affected	Affected	Badly Affected	Affected	......	......
	D	V. Sl. Cloudy	1	45.4			3¾	Yes	Sl. Affected	Unaffected	Affected	Sl. Affected	......	......
E. J. Cole	A	Clear	1	47.2	70	30	1½	Yes	Unaffected	Unaffected	Sl. Affected	Unaffected	80 - 90	80 - 90
	B	Clear	5	53.7			5¾	No	Sl. Affected	Unaffected	Badly Affected	Unaffected	60 - 70	60 - 70
	C	Clear	2	46.0			5½	No	Badly Affected	Unaffected	V. Badly Affected	Unaffected	20 - 30	20 - 30
	D	Clear	1	45.5			2¾	Yes	Unaffected	Unaffected	Badly Affected	Unaffected	0 - 10	0 - 10
H. A. Gardner	A	Clear	1	48.2	70 - 77	..	1¾	Yes	Unaffected	Unaffected	Unaffected	Unaffected	70 - 80	70 - 80
	B	Clear	6	53.5			5½	No	Sl. Affected	Unaffected	Badly Affected	Unaffected	60 - 70	60 - 70
	C	Sl. Turbid	2	46.5			6	No	Badly Affected	Badly Affected	V. Badly Affected	Badly Affected	50 - 60	40 - 50
	D	Sl. Turbid	1	46.3			2¾	Yes	Sl. Affected	Unaffected	Badly Affected	Unaffected	0	0
E. C. Holton	A	Clear	..	47.4	..	..	..	..	....	....	Sl. Affected	Unaffected	80 - 90	90 - 100
	B	Clear	..	52.7	..	..	..	..	....	....	Badly Affected	Unaffected	70 - 80	70 - 80
	C	Sl. Cloudy	..	45.9	..	..	..	..	....	....	Badly Affected	Sl. Affected	50 - 60	50 - 60
	D	Sl. Cloudy	..	45.8	..	..	..	..	....	....	Badly Affected	Sl. Affected	10 - 20	10 - 20
F. P. Ingalls	A	Clear	1	47.3	74	..	3	Yes	Unaffected	Unaffected	Unaffected	Unaffected	50 - 60	50 - 60
	B	Clear	5	51.8			6½	Yes	Sl. Affected	Unaffected	Sl. Affected	Unaffected	50 - 60	50 - 60
	C	Clear	2	45.1			7	Yes	Sl. Affected	Unaffected	Sl. Affected	Unaffected	10 - 20	10 - 20
	D	Clear	1	44.9			4	Yes	Sl. Affected	Unaffected	Sl. Affected	Unaffected	0	0
A. H. Sabin	A	Clear	1	47.2	78.3	..	1¼	Yes	V. Sl. Affected	Unaffected	Sl. Affected	Unaffected	60 - 70	......
	B	Clear	6	51.7			4¼	No	Sl. Affected	Unaffected	Affected	Unaffected	40 - 50	......
	C	Clear	2	45.3			4¼	Yes	Badly Affected	Sl. Affected	Badly Affected	Affected	40 - 50	......
	D	Clear	1	44.2			2½	Yes	Sl. Affected	Sl. Affected	Affected	Unaffected	0	......
J. M. Saunderson	A	Clear	1	48.2	70	..	2	Yes	Unaffected	Unaffected	Unaffected	Unaffected	70 - 80	......
	B	Clear	5	53.2			5½	No	Sl. Affected	Unaffected	Sl. Affected	Unaffected	60 - 70	......
	C	Clear	2	44.6			4½	No	Badly Affected	Badly Affected	Badly Affected	Unaffected	30 - 40	......
	D	Clear	1	45.6			3	Yes	Sl. Affected	Unaffected	Sl. Affected	Unaffected	20 - 30	......

TABLE I—SUMMARY OF RESULTS OF VARNISH TESTS BY VARIOUS OPERATORS.—(*Continued.*)

Operator.	Sample.	Appearance.	Color.	Non-Volatile Matter.	Drying.				Water Resistance (Cold Water).		Water Resistance (Hot Water).		Elasticity (Kauri Reduction Test).	
					Average Temperature, deg. Fahr.	Relative Humidity, per cent.	Drying to Touch, hr.	Drying Hard and Tough in 24 hr.	On Removal.	2 hrs. after Removal.	On Removal.	2 hrs. after Removal.	Using Standard "Run Kauri"	Using Own "Run Kauri"
L. L. Steele	A	Clear	1	46.9	76	20	1	Yes	V. Sl. Affected	Unaffected	V. Sl. Affected	Unaffected	60 - 70	60 - 70
	B	Clear	6	53.5			3½	Yes	Sl. Affected	Unaffected	Badly Affected	Badly Affected	30 - 40	30 - 40
	C	Clear	2	45.7			3½	Yes	Badly Affected	Badly Affected	Badly Affected	Badly Affected	10 - 20	10 - 20
	D	Clear	1	45.5			2¼	Yes	Unaffected	Unaffected	Badly Affected	Badly Affected	0	0
E. A. Stoppel	A	Clear	1	47.0	76	..	1½	Yes	Unaffected	Unaffected	Unaffected	Unaffected	60 - 70	60 - 70
	B	Clear	5	52.6			4½	Yes	Sl. Affected	Unaffected	Affected	Unaffected	40 - 50	40 - 50
	C	Clear	2	45.5			6	Yes	Badly Affected	Unaffected	Badly Affected	Unaffected	10 - 20	10 - 20
	D	Clear	1	45.3			3	Yes	Unaffected	Unaffected	Badly Affected	Unaffected	0	0
E. E. Ware	A	Clear	1	47.1	78	..	1¼	Yes	Unaffected	Unaffected	....	....	90 - 100	100 - 110
	B	Clear	6	53.7			5½	No	Sl. Affected	Unaffected	....	....	60 - 70	100 - 110
	C	Sl. Cloudy	2	46.0			4½	No	Badly Affected	Unaffected	....	....	40 - 50	60 - 70
	D	Sl. Cloudy	1	45.5			1¾	Yes	Sl. Affected	Unaffected	....	....	10 - 20	10 - 20
F. A. Werts	A	Clear	½	46.9	73	..	3½	Yes	V. Sl. Affected	Unaffected	V. Sl. Affected	Unaffected	60 - 70	60 - 70
	B	Clear	7	52.5			6	Yes	Sl. Affected	Unaffected	Badly Affected	Unaffected	30 - 40	30 - 40
	C	Clear	2	45.8			8¾	Yes	Badly Affected	Sl. Affected	Badly Affected	Sl. Affected	10 - 20	10 - 20
	D	Clear	1	45.4			4¼	Yes	Sl. Affected	Unaffected	Badly Affected	Unaffected	0	0
C. L. Sargent	A	Clear	1	47.6	72	65	2¾	Yes	Unaffected	Unaffected	V. Sl. Affected	Unaffected	70 - 80	70 - 80
	B	Clear	5	53.4			4¼	No	Sl. Affected	Unaffected	Badly Affected	Sl. Affected	50 - 60	50 - 60
	C	Clear	2	46.1			8¼	No	Badly Affected	Unaffected	Badly Affected	Badly Affected	50 - 60	50 - 60
	D	Clear	1	45.4			5½	Yes	Unaffected	Unaffected	Badly Affected	Unaffected	0	0
R. W. Linsay	A	Clear	1	46.8	82	68	3½	Yes	V. Sl. Affected	V. Sl. Affected	V. Sl. Affected	V. Sl. Affected	60 - 70	60 - 70
	B	Clear	5	52.7			8	Yes	Sl. Affected	V. Sl. Affected	Badly Affected	Sl. Affected	30 - 40	30 - 40
	C	Clear	2	45.1			11½	No	Badly Affected	V. Sl. Affected	Badly Affected	Badly Affected	Below 30	Below 30
	D	Clear	1	45.5			4½	Yes	V. Sl. Affected	V. Sl. Affected	Badly Affected	Sl. Affected	Below 30	Below 30
Average				47.4 52.7 45.6 45.4										

of the average in each case. Differences of 1½ cm. in the diameter of the pan used does not affect the results. It is important to have the oven well ventilated.

Drying Time.—Reports are not in close agreement. The terms "dry to touch" and "dry hard and tough" will require more exact definitions. This will be considered in future work.

Cold Water Tests.—Reports are in good harmony. The interpretation of this test and its value is still to be considered. It is noted that those varnishes which are affected are for the most part unaffected two hours after removal from the water.

Hot Water Test.—With the possible exception of varnish *D*, this test seems to be a more rapid and severe cold water test. Varnish *D* is more affected than would be expected from the results in the cold water test. Two hours after removal from the hot water, varnishes are, with the exception of varnish *C*, unaffected.

Cooling the hot water to room temperature before removing the panel does not seem to improve the test or alter the results.

Elasticity as Determined by the Kauri Reduction Test.—Results are in fair agreement. One of the difficulties encountered is finding a proper oven. It is not sufficient that the thermometer on the oven indicate that there has been no variation, but the various parts of the oven must not differ in temperature. In other words, the various varnished plates must all be baked at the correct temperature. Any oven that is to be used for this test should be carefully tested for uniformity before it is used.

In the majority of cases, the gum prepared by the operator gave the same results as the standard Run Kauri. Report on this work will be completed during the year.

Durability by Exposure.—The exposure tests of the samples have not progressed far enough to be included in this year's report.

Viscosity.—Several members have reported the viscosity of the various samples, using the Gardner-Holdt Bubble Viscosimeter. By this method, the various varnishes are compared in tubes of equal diameter to secondary standards of known absolute viscosity, at a definite temperature. The viscosity of a varnish has an important part to play in its working properties. This method of determining viscosity is both simple and inexpensive. The results obtained appear to be well within the accuracy necessary for varnish work.

The following table shows the figures obtained by different operators with different sets of viscosity tubes.

VISCOSITY IN POISES AT 25° C.

SAMPLE.	GARDNER.	INGALLS.	COLE.	STOPPEL.
A	1.40	1.50	1.40	1.65
B	1.30	1.40	1.25	1.40
C	3.40	3.40	3.40	3.20
D	3.30	3.30	3.20	3.20

Thickness of Film.—Several members are doing work on the thickness of the various varnish films which are used in the tests and this will be reported later.

Respectfully submitted on behalf of the sub-committee,

E. J. COLE,
Chairman.

REPORT OF SUB-COMMITTEE XIV ON PREPARATION OF IRON AND STEEL SURFACES FOR PAINTING.

Sub-Committee XIV reports that very little change has taken place in the condition of the panels of the tests which are in progress to determine the effect of various treatments of surface on the holding property of paints, and there is, therefore, nothing of importance to add to the report of last year as regards the original panels.

Panel No. 10 of the Brooklyn tests was found in such bad condition at the sub-committee inspection of May 27, 1921, that it seemed that there would be no advantage in exposing it further, but it was thought that it could be utilized for further tests to determine the relative value of sand-blasting and ordinary cleaning. The plate was, therefore, sent to Dr. McDonnell at Altoona who reported treatment and exposure of the same as follows:

> "On June 9, 1921, the right half of the panel was carefully scraped and wire brushed. The left half of the panel was sand-blasted and all old paint, rust and scale removed thereby. The entire panel was then coated with Pennsylvania Railroad freight-car paint. On June 10 the second coat of the same paint was applied, 24 hours having elapsed since the application of the first coat. The paint used was taken from a quart can which was made up by Mr. Cheesman for the original test, which had been kept unopened until June 9, 1921. On June 10 the panel was stenciled on the face with the figure '10' and the word 'Scraped' on the left end and 'Sand-blasted' on the right end. The back of the panel was also given one coat of Pennsylvania standard black paint for the purpose of preserving it. The panel was exposed on the test rack with other panels belonging to Sub-Committee XIV on June 13."

Respectfully submitted on behalf of the sub-committee,

A. W. CARPENTER,
Chairman.

REPORT OF SUB-COMMITTEE XXI ON SPECIFICATIONS FOR THE FUNDAMENTAL REQUIREMENTS OF PAINT FOR SPECIFIC PURPOSES.

Sub-Committee XXI has carefully considered the various requirements of paint, and it seems evident that much progress has been made in methods of testing and instruments for determining color, hiding power, surface finish and consistency. At the present time, the attention of the sub-committee is largely given to the question of durability, and the possibility of developing accelerated durability tests. The sub-committee is trying to study the different factors that influence durability, and hopes to have something more definite to report next year.

The sub-committee feels that it has stimulated the study of these problems by other members of Committee D-1 and the paint industry in general.

Respectfully submitted on behalf of the sub-committee.

F. G. Breyer,
Chairman.

REPORT OF SUB-COMMITTEE XXII ON METHOD OF APPLICATION OF PAINT BY SPRAYING.

TEST AT BRIDGEVILLE, PA. (MCLAUGHLIN ROAD), ON OCTOBER 11 AND 13, 1921.

At the meeting of March 22, 1921, of Committee D-1, at Philadelphia, the chairman of the sub-committee recommended a competitive spraying and brushing test under actual working comparable conditions. Accordingly, permission was obtained from the Pittsburgh Coal Co., owners of a row of six small dwelling houses of uniform size and location shown in Fig. 1, to have some of these houses painted by brushing and others by spraying, simultaneously. The owners agreed to pay for the paint, and the committee agreed to supply the labor without charge.

Fig. 2 is a close-up view of a typical house. These houses, so far as can be learned, were painted about twelve years ago and Fig. 3 shows the average condition of the surface on all of them. It is considered that so far as uniformity of area and condition of surface are concerned, the houses were practically identical.

All of the leading spray apparatus manufacturers were asked to participate, and the invitation was accepted by W. N. Matthews and Brother, The DeVilbiss Manufacturing Co. and the Paasche Air Brush Co. The Spray Engineering Co., Boston, and the Eclipse Air Brush Co. did not wish to participate in the test. On account of some mishap which occurred in shipping the machine, the Paasche Air Brush Co., was unable to get their machine in operation in time to participate; but with the DeVilbiss Manufacturing Co. and W. N. Matthews and Brother, together with a non-union group of three painters, and a union group of three painters, the test was started on Tuesday morning, October 8, with four houses to be painted.

A second group of union painters had been employed to do a fifth house, but when they arrived on the job and found non-union workers next door, they refused to work, but it was considered that with two of the leading spray apparatus manufacturers and a union and a non-union crew of brush painters, there would be sufficient data from which to draw conclusions.

The color scheme for the painting was as follows:

Body of Houses, Gray—2 houses sprayed, 2 houses brushed.
Trim, White—4 houses brushed.
Window Sash, Black—4 houses brushed.

The committee decided on Bureau of Standards Inter-departmental White Paint conforming to Specification No. 89:

White Lead	31 per cent
XX Zinc Oxide	25 "
Silicate of Magnesium	6 "
Raw Linseed Oil	32 "
Japan Dryer	6 "
	100 per cent

Thinning.—The paint on the above formula was made up by W. W. Lawrence & Co. and sent in 5 and in 1-gal. cans to the job.

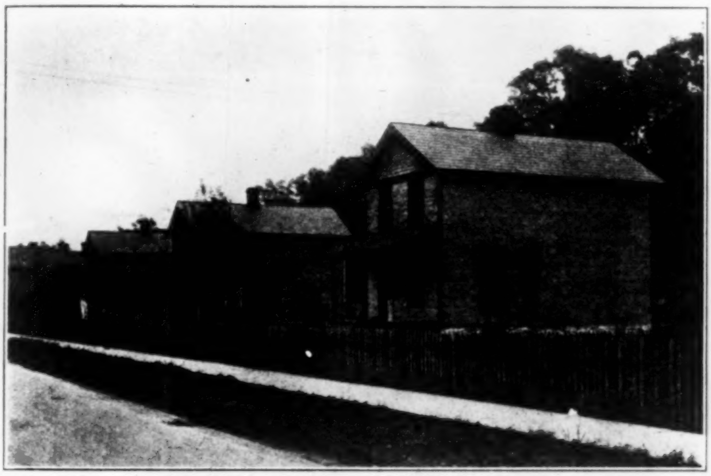


FIG. 1.—Dwelling House Used in Spraying *versus* Brushing Paint Tests.

After consulting the practical painters and considering the recommendations of the spray workers, it was decided that the gray paint for the body of the house in its original form was too heavy for both brushing and spraying, and in order to get a comparison between brushing and spraying with exactly the same mix of paint, a gallon of turpentine was added to each 5 gal. of paint used for the first coat, and thus the same paint was used by both brush and spray workers. To the white trim paint for the first coat, 1 pt. of turpentine was added to each gallon.

For the second coat, $\frac{1}{4}$ gal. of turpentine was used to each 5 gal. can of gray paint; and $\frac{1}{2}$ pt. of turpentine to the white for finishing. The figures given in the report and all data which follow represent the paint as thinned for use in this manner, and to this extent, corrections must be made in the above formula No. 89 to ascertain the exact nature of the paint applied for each coat.

As cost of these paints, a price of $2.50 per gallon was agreed upon as a fair market price, and this figure is used in all calculations.

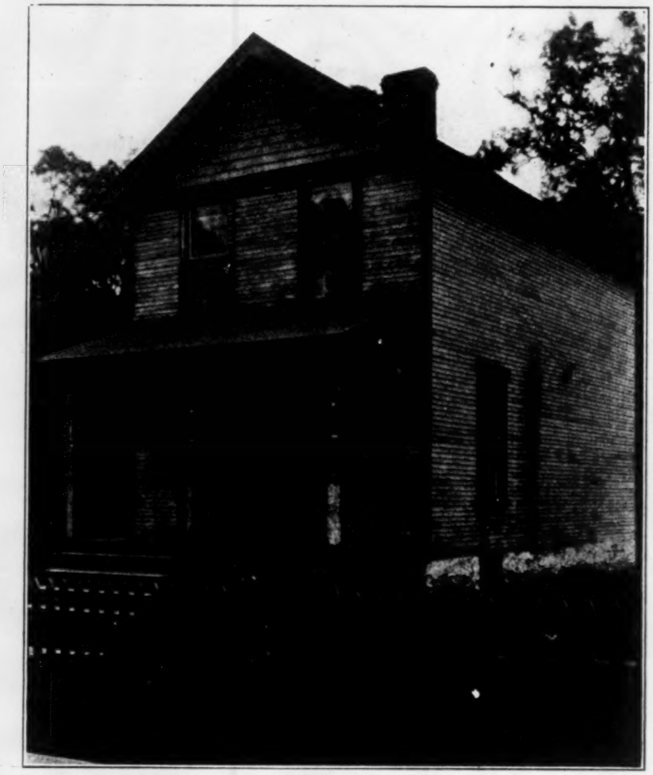


FIG. 2.—A Typical House.

As a means of scaffolding the buildings, it was decided that the Bauer safety ladders which are shown in Fig. 4 would be satisfactory, and accordingly the Bauer Manufacturing Co., Wooster, Ohio, kindly consented to loan sufficient ladders and planks for the work.

Each house was started independently as it was not found practicable to start the work simultaneously. The scaffolding apparatus was lying in the yard and the time of placing the ladders and planks in position was included in the working time.

Each house presented an area of 1750 sq. ft. for each coat, which included the porch, but did not include the windows. All calculations on the tabulated statements herein employ 1700 sq. ft. after making allowance for the windows.

DETAILS OF WORK.

House No. 1, Non-Union, Brush.—

Job in charge of F. J. Nickolay, Contractor, Bridgeville, Pa.

A.S.T.M. Overseer, J. F. Nieser of the Arco Co., Cleveland, Ohio.

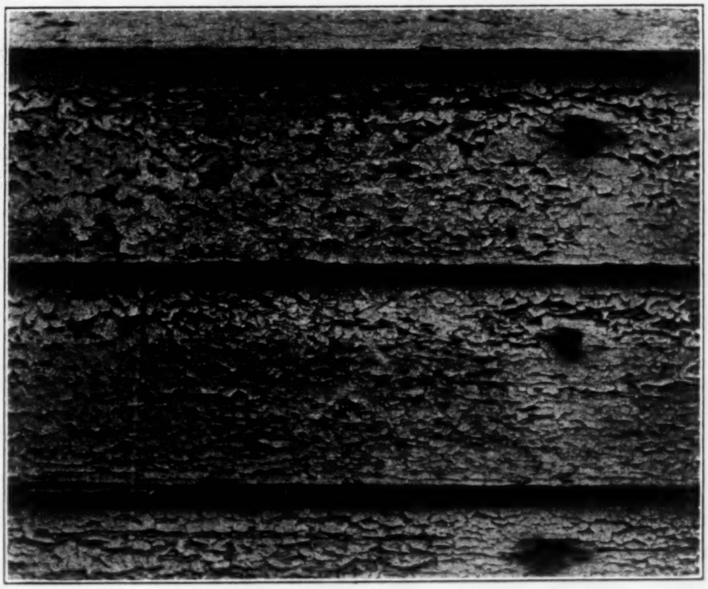


FIG. 3.—Average Condition of Surface.

Paint brushed by three non-union men. The old paint was badly checked. The men employed on this job worked about as fast as the average good hand brush man would. This job was about as good as House No. 3.

House No. 2, Spray, W. N. Matthews and Brother.—

Job in charge of J. B. Trescott, St. Louis, Mo.

A.S.T.M. Overseer, Frank Gutenberg, of the Acme White Lead and Color Works, Detroit, Mich.

Old trim was dark red. The body of the house a dirty light drab. A fairly heavy coat of primer was applied with both spray and brush; the primer did not seem to fill the bad spots thoroughly. The surface was not thoroughly wire brushed. Where surface was hard, that is, where paint was not all off surface, a few runs showed.

None of the three workers on the second coat were good brush hands. The spray did not fill in bad spots, especially where the old paint was badly checked or weather beaten.

House No. 3, Union Men, Brush.—

Job in charge of C. T. Singhouse, Contractor, Pittsburgh, Pa.

A.S.T.M. Overseer, H. A. Nelson, of the New Jersey Zinc Co., Palmerton, Pa.

This job was probably the best of the four houses. The work was very good, because the workmen were experts and the house was scraped and sanded and in fair condition for painting. It had a solid coat.

House No. 4, Spray, DeVilbiss Manufacturing Co., Toledo, Ohio.—

Job in charge of W. F. Gradolph, DeVilbiss Manufacturing Co., Toledo, Ohio.

A.S.T.M. Overseer, C. D. Holley, of the Sherwin-Williams Co., Cleveland, Ohio.

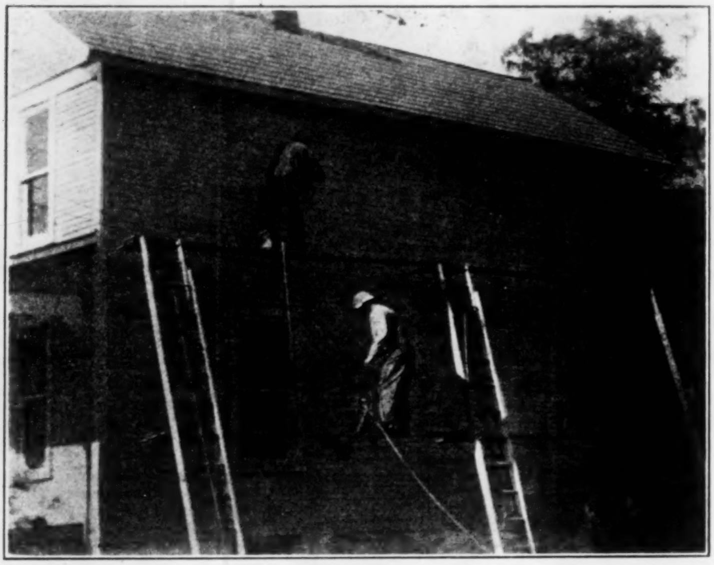


FIG. 4.—Scaffolding and Spray Apparatus in Use.

Old trim was dark red. A very light priming coat was applied, apparently in many places insufficient to properly seal the surface. The application appeared rather uneven, too light in spots and slightly heavy in others but with no runs or sags. It took 9 minutes to make connections, erect staging and clean up. It took 30 minutes to do the east side, 29 minutes to do the west side and 44 minutes to do the back. Two men were used on this job. The surface was not cleaned as well as it should be for good painting. The first coat was not as dry in places where paint was applied heavy as it should be for re-coating.

Conclusions.—

1. The hand brush application undoubtedly showed a superior evenness and penetration in the cracks and crevices of this rough

surface. Brush application proved superior to spraying where a surface of this kind is to be contended with; therefore, having this in mind a subsequent spray test was made on one of these houses having the same rough surface. A few minutes after the paint was sprayed it required only a few minutes, by means of a 4-in. brush, to brush the sprayed paint so that it filled the cracks and crevices, and had the same appearance as the paint applied entirely by brush. It required an astonishingly short time to level off the paint in this manner and get the same effect with sprayed as with brushed paint.

TABLE I.—TIME AND COST COMPARISON IN PAINTING FOUR HOUSES.
Brush *versus* Spray.

House	Method.	Coats.	Painting Time.				Area, sq. ft.	Area per Minute, 3 Men, sq. ft.	Labor Cost at $1.35 per Hour, dollars.		Remarks.
			1 Man.		3 Men.				Total.	Per Square Foot.	
			hr.	min.	hr.	min.					
No. 1	Brush, 3 Non-Union Men	First....	3	55	11	45	1700	2.41	34.08	0.01002	Time cleaning, 3 men at 4 hours each = 12 hr.[1] Trimming time included in total time, 4 hr. 6 min. Paid contractor for job. $63.25, or $0.0185 per sq. ft. Labor cost 72 hr. at $0.876 per hr.
		Second..	4	30	13	30	1700	2.10			
		Total....	8	25	25	15	3400				
		Average.	.....	.....	.....	.....	......	2.25			
No. 2	Spray, W. N. Matthews and Bro. 3 Men	First....	3	18	9	54	1700	2.86	27.85	0.0082	Time cleaning, 3 men, 1 hr each. Total 3 hr.[1]
		Second..	3	33	10	39	1700	2.66			
		Total....	6	51	20	33	3400				
		Average.	.....	.....	.....	.....	......	2.75			
No. 3	Brush, 3 Union Men	First....	2	12	6	36	1700	4.29	17.83	0.00525	Time cleaning, 3 men 1 hr. 10 min. each = 3 hr. 30 min.[1] Trimming included in total time, 4 hr. 15 min. Paid contractor for job 48 hr. at $1.35 per hr., $64.80, or $0.019 per sq. ft.
		Second..	2	15	6	45	1700	4.20			
		Total....	4	27	13	21	3400				
		Average.	.....	.....	.....	.....	......	4.24			
No. 4	Spray, DeVilbiss, 2 Men				2 Men.			2 Men.	16.20	0.00477	One man cleaning 5 hr.[1]
		First....	3	3	6	6	1700	4.64			
		Second..	2	57	5	54	1700	4.80			
		Total....	6	0	12	0	3400				
		Average.	.....	.....	.....	.....	......	4.72			

[1] Time cleaning not included in total cost of job or total time.

2. This test developed the fact that for small houses of this character, where it is necessary to paint the body one color and the trim in another color, the spray does not show as great economy in application as one would expect, but against this is the fact that both crews of brush painters worked very rapidly, one crew especially, at a rate of speed that would hardly apply in regular practice. Also, the time included in working time required to connect up the spraying

TABLE II.—QUANTITY OF PAINT USED, IN GALLONS, AND AREA COVERED PER GALLON, SHOWING COST OF MATERIAL AND LABOR PER SQUARE FOOT.

House.	Method.	Paint Used, gal.		Application, sq. ft. per gal.	Cost of Paint at $2.50 per Gallon, dollars.	Cost per Square Foot, dollars.			Total Cost, dollars.
						Material.	Labor.	Material and Labor.	
No. 1	Brush, 3 Non-Union Men	1st Coat Gray.....	5.						
		1st Coat White....	0.875						
		Total...	5.875	289	14.69	0.00864			
		2d Coat Gray.....	3.2500						
		2d Coat White....	0.6875						
		2d Coat Black.....	0.0630						
		Total...	4.0005	425	10.00	0.00588			
		Total, 2 coats.......	9.8755		24.69				
		Average....................		344		0.00726	0.01002	0.01728	58.75
No. 2	Spray, W. N. Matthews and Bro., 3 Men	1st Coat Gray.....	5.125						
		1st Coat White....	0.625						
		Total...	5.750	295	14.38	0.00847			
		2d Coat Gray.....	4.000						
		2d Coat White....	1.000						
		2d Coat Black.....	0.063						
		Total...	5.063	336	12.66	0.00744			
		Total, 2 coats.......	10.813		27.04				
		Average....................		314		0.00795	0.0082	0.01615	54.91
No. 3	Brush, 3 Union Men	1st Coat Gray.....	5.500						
		1st Coat White....	1.125						
		Total...	6.625	257	16.56	0.00974			
		2d Coat Gray.....	3.750						
		2d Coat White....	1.125						
		2d Coat Black.....	0.063						
		Total...	4.938	344	12.35	0.00727			
		Total, 2 coats.......	11.563		28.91				
		Average....................		294		0.00850	0.00525	0.01375	46.75
No. 4	Spray, DeVilbiss, 2 Men	1st Coat Gray.....	4.125						
		1st Coat White....	0.500						
		Total...	4.625	368	11.56	0.00680			
		2d Coat Gray.....	3.875						
		2d Coat White....	1.000						
		2d Coat Black.....	0.063						
		Total...	4.938	344	12.35	0.00727			
		Total, 2 coats.......	9.563		23.91				
		Average....................		356		0.00703	0.00477	0.01180	40.12

equipment and clean up the outfit afterward are items which assume considerable importance on a small three-hour job, while on a larger job this item would be negligible.

3. If the houses had been painted all one color over the body and trim, the spray apparatus manufacturers would have made a much better time and cost showing. In the case of House No. 2 (W. N. Matthews and Brother) the trim color was applied by inexperienced brush painters, and if it had not been for this, we believe House No. 3 would have made a still more favorable showing as to time and cost.

4. We believe Tables I and II afford reliable figures as to the cost of paint and labor per square foot between brushing and spraying where the conditions were all unfavorable to the spray method. We believe these figures afford a reliable basis for painting calculations and that they will prove valuable for comparisons in further work. The number of square feet to the gallon of paint consumed on the four jobs ranging from a minimum of 257 sq. ft. per gallon to a maximum of 425 sq. ft. per gallon, should be noted particularly.

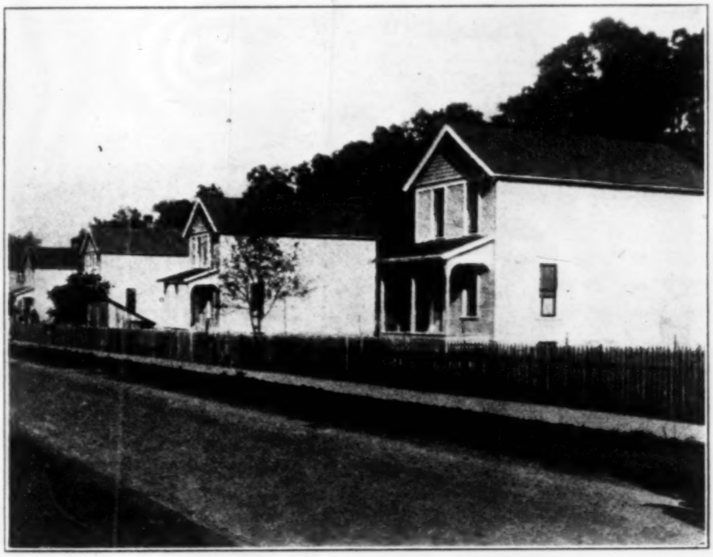


FIG. 5.—Appearance of Houses with Painting Completed.

5. Contrary to our expectations, apparently no more paint was used in spraying than in brushing. The two spray outfits used less paint than the two brush crews, and the finished houses show a difference in appearance in proportion to the paint consumed.

6. Although seven months have gone by since this test was completed, there has been no formal inspection to report on the weathering of the paints. Formal inspection will take place in October, 1922, after one year's exposure. An informal inspection made seven months after the test was completed shows all of the paints in about the same condition.

7. Having completed the test with regard to small houses and rough surfaces, the committee believes that the next test should be on larger and smoother surfaces, and the results calculated over a period of several days of working rather than for one short task.

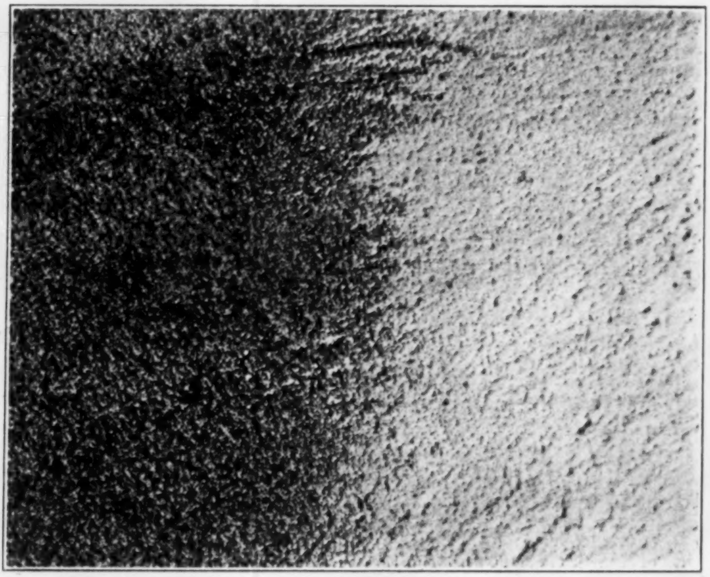


FIG. 6.—Interior Cement Finish before Painting.

COMPARATIVE TEST OF INTERIOR PAINTING ON CEMENT FINISHED PLASTER AT CARNEGIE, PA., OCTOBER 12, 1921.

Three identical wall spaces of soiled and unpainted cement plaster (see Fig. 6) in a large hall in Carnegie, Pa., were marked off; each having an area of 205 sq. ft. On space No. 1, two expert brush men coated the surface in 17¼ minutes. On space No. 2, one spray man (Matthews) coated the surface in 12½ minutes and on space No. 3, one spray man (DeVilbiss) covered the space in 12 minutes. Both of the areas sprayed showed considerably better hiding than the brushed space. The brush men worked at extreme speed.

On the ceiling work, two men, one using a Matthews Gun and the other a DeVilbiss, sprayed 3400 sq. ft. in 2 hours and 15 minutes.

Taking the ceiling and wall work together, 4000 sq. ft. were sprayed with 29 gal. of paint, one coat, giving much better hiding than the brush work.

TABLE III.—INTERIOR PAINTING COMPARATIVE TEST.

Brush *versus* Spray on Cement Finished Plaster in Large Hall at Carnegie, Pa., October 12, 1921.

		Method.	Painting Time.		Area, sq. ft.	Area per Minute, sq. ft.		Cost per Section at $1.35 per Hour, dollars.	Cost per Square Foot, dollars.
			2 Men, min.	1 Man, min.		1 Man.	2 Men.		
Wall Section	No. 1	Brush, 2 Men	$17\frac{1}{4}$	$34\frac{1}{2}$	205	5.95	.....	0.776	0.00378
	No. 2	Spray, 1 Man, Matthews Outfit	...	$12\frac{1}{2}$	205	16.40	.....	0.2812	0.00137
	No. 3	Spray, 1 Man, DeVilbiss Outfit	...	12	205	17.80	.....	0.27	0.00131
Ceiling	2 Men	Spray: 1 Matthews Gun 1 DeVilbiss Gun	135	270	3400	12.59	25.19	6.08	0.00179

Twenty-nine gallons of paint used on 4000 sq. ft. of walls and ceiling, or 138 sq. ft. per gal. of paint. Material cost per sq. ft. at $2.50 per gal., $0.01810. Total, $0.01989.

The paint used in this test was very heavy flat wall finish in white. This test developed that it is possible on this class of work to get much better hiding with the spray than by brushing, for there is less rubbing up of the dust and dirt into the wet paint; moreover, more paint per coat can be applied with the spray than by hand brushing.

Respectfully submitted on behalf of the sub-committee,

R. E. ROGERS,
Chairman.

REPORT OF SUB-COMMITTEE XXIII ON ANTI-FOULING PAINTS.

Organized late in 1921, the sub-committee was able to plan only a limited series of tests for summer and fall exposure. It was decided to put out test plates in Raritan Bay, N. J., and duplicate plates at Charleston, S. C., representing various toxics or poisons and types of anti-corrosive and anti-fouling vehicles.

Three types of anti-corrosive vehicles were selected over which three anti-fouling compositions designed for the particular anti-corrosive first coat were applied. Red lead paint was also used as the anti-corrosive under each of the anti-fouling compositions. In addition, a specially designed anti-corrosive and anti-fouling paint was applied to one panel for comparative purposes.

Five panels were prepared with anti-corrosive or red lead paint for each set, over which various anti-fouling compositions were applied, each panel being divided into ten sections.

The pigment compositions of the various anti-fouling preparations were designed to represent various proportions of single toxics or poisons or mixtures of these used with each of the anti-fouling vehicles selected. The balance of the pigment portion was made up of a mixture of Spanish oxide, zinc oxide and asbestine to a standard percentage of 40 in all anti-fouling compositions, thus giving a vehicle percentage of 60. The poisons used were yellow mercuric oxide, mercuric arsenate, mercuric phenate, mercuric oleate, cupric oxide, cuprous cyanide, zinc cyanide and zinc stearate. It was hoped that each poison could be assigned a definite numerical toxic value. We define a unit as the toxic power of poisonous ingredients such that it will require as a minimum 100 total units in 100 parts by weight of standard ship bottom paint in order for it to give satisfaction on a merchant vessel in tramp service. For example, if it is found that an anti-fouling paint containing not less than $8\frac{1}{3}$ per cent of yellow mercury oxide is satisfactory on merchant vessels, or $8\frac{1}{3}$ parts for 100 parts of paint, giving 100 total units of toxic power, by definition, then we have $8\frac{1}{3}$ distributed over 100 or 12 units for each 1 per cent of toxic ingredient.

Various unit values were arbitrarily adopted for each poison in selecting the percentage to be used in the pigment portion, with the expectation that the results of the tests would show the proper unit value for each poison.

For example, in Panels Nos. 2, 7, 12, 17, 22 and 27 the following units were adopted as perhaps approaching the correct figure for each of the eight toxics used:

Yellow mercury oxide	12
Mercuric arsenate	12
Mercury phenate	11
Mercury oleate	8
Copper cyanide	8
Copper oxide	5
Zinc cyanide	6
Zinc stearate	3

Thirty steel panels representing six sets of anti-corrosive and anti-fouling compositions and 300 coatings were immersed in Raritan Bay, N. J., on August 20, 1921, being inspected and rated by committee members on October 3, 1921, and again on December 14, 1921, after which these tests were discontinued until the next year (1922).

Duplicate panels were immersed in Charleston, S. C., harbor on August 31, 1921, and were inspected on October 31, 1921, and on February 13, 1922, and then discontinued.

Photographs of the plates were taken at each inspection.

The inspectors were:

Raritan Bay.—First inspection: A. M. Muckenfuss, G. D. White, A. C. Holzapfel.

Second inspection: A. M. Muckenfuss, G. D. White, R. L. Hallett.

Charleston.—First inspection: A. C. Holzapfel, Lieutenant Hermann of Charleston Navy Yard.

Second inspection: Commandant C. W. Fisher of Charleston Navy Yard.

The value of the different compositions were judged both as to the preservation of the steel and the anti-fouling properties, that is, the power of preventing growths or accumulation of marine matter. The tests indicate that certain of the anti-corrosive compositions have real merit and certain anti-fouling vehicles together with a particular poison or mixture of poisons give excellent results. Due to the great number of compositions tested and from the contradictory results secured, it was not possible to decide numerical unit toxic values for the different poisons and the results in general merely indicate preliminary data for further experiments in 1922.

RESULTS OF INSPECTION.

In presenting the results on each panel immersed in sea water, the photographs of the Raritan panels at the time of the first inspection are shown with the exception of Fig. 13, in which case the panel exposed at Charleston is shown at the time of the second inspection.

Below the photograph is a diagram of the panel in the position in which it was immersed, showing the position of each paint. On the space for each paint, in the middle is put the percentage of toxic ingredient in the whole composition, the following symbols being used:

A, Mercury oxide, yellow;
B, Mercuric arsenate;
C, Mercury phenate;
D, Mercury oleate;
E, Copper cyanide;
F, Copper oxide, scale;
G, Zinc cyanide;
H, Zinc stearate.

The upper and lower paints on each panel consist either of only one coat of anti-corrosive paint or of the standard used for comparison, Norfolk Navy No. 19. This latter consisted of:

Indian red	12.43	per cent
Mercury oxide, red	6.22	"
Zinc oxide	12.96	"
Wood alcohol	42.60	"
Shellac A	12.42	"
Pine tar oil	6.68	"
Turpentine	6.68	"

To each of the eight paints in a panel, the following base pigment was added, enough to make a total of 40 per cent of pigment in each paint.

Zinc oxide	24.3	per cent
Spanish red oxide	57.1	"
Asbestine	18.6	"

Every set of five panels contained a different combination of anti-corrosive paint and anti-fouling vehicle. In all cases, the latter was 60 per cent of the paint.

In Panels Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, the following was the composition of the anti-fouling vehicle (No. 1):

Rosin	40	per cent
Raw linseed oil	6	"
Ozokerite	2	"
Petroleum spirits	52	"

One coat of anti-corrosive paint was applied. This was followed by one coat of anti-fouling paint. The first was allowed to dry 24 hours and the last, 24 hours, before immersion, except the delay noted in the case of Charleston. The red lead was allowed to dry for four days.

In Panels Nos. 1, 2, 3, 4, and 5, the following was the composition of the anti-corrosive paint (No. 1):

Spanish red oxide	20	per cent
Asbestine	10	"
Stearine pitch	12.66	"
Gilsonite asphalt	12.66	"
Coal-tar oil	44.67	"

In Panels Nos. 6, 7, 8, 9, 10, 16, 17, 18, 19, 20, 26, 27, 28, 29, and 30, the anti-corrosive paint was the following (No. 2):

Red lead (98 per cent Pb_3O_4)	79.69	per cent
Raw linseed oil	19.31	"
Turpentine dryer	1.00	"

In Panels Nos. 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20, the anti-fouling vehicle was (No. 2):

Wood alcohol	4 pints, 3 gills
Shellac A	1 lb. 8 oz.
Pine tar oil	3 gills
Turpentine	3 gills

In Panels Nos. 11, 12, 13, 14, and 15, the anti-corrosive was Norfolk Navy No. 17 (No. 3):

Wood alcohol	52.89	per cent
Shellac A	6.58	"
Turpentine	4.32	"
Pine tar oil	4.32	"
Zinc dust	8.10	"
Zinc oxide	24.29	"

Norfolk No. 17 was also the anti-corrosive under Norfolk No. 19.

In Panels Nos. 21, 22, 23, 24, 25, 26, 27, 28, 29, and 30, the composition of the anti-fouling vehicle was (No. 3):

Crude mineral oil	21 lb.
Pale gloss oil	36 lb.
Benzol	3 gal.
Grinding japan	3 gal.

In Panels Nos. 21, 22, 23, 24, and 25, the composition of the anti-corrosive paint was (No. 4):

Aluminum stearate	30 lb.
English china clay	200 lb.
60-per-cent brown oxide	800 lb.
Purple oxide	1400 lb.
Red lead	500 lb.
Rubbing varnish	300 lb.
Grinding japan	500 lb.
Petroleum spirits	100 lb.

Benzol	19 gal.
Pale gloss oil	19 gal.
Naphtha	50 gal.

All spaces marked "no second coat" were so treated because the calculated percentages of toxic ingredient were too great for proper application of the paint.

Certain other spaces were given a coat of Norfolk No. 19 because the compositions as made up coagulated. This applies to second coats. In such cases, Norfolk No. 17 was not used as first coat, which was the same as contiguous paints.

Panel No. 31 consisted of special paints, each of independent composition. The first four contained uranium oxide and formed a group. The compositions follow:

On Panel No. 31, the left side (five paints) received one coat of the same anti-corrosive as Panels Nos. 1 to 5, inclusive, namely, the stearine pitch anti-corrosive.

The right side (one paint) received two coats of the following anti-corrosive:

Zinc dust	1 lb.
Zinc oxide	3 lb.
Ester gum liquid	3 qt.

Paints Nos. 301, 302, 303, 304, and 305 received second coats of anti-fouling paint containing 60 per cent of the same anti-fouling vehicle as Panels Nos. 1 to 10, inclusive, namely, the rosin-linseed varnish.

The pigments of the first four anti-fouling paints were:

Percentages in whole paint:	PAINT No. 301.	PAINT No. 302.	PAINT No. 303.	PAINT No. 304.
Zinc oxide	10	10	10	8
Iron oxide	17	16	15	14
Asbestine	12	1	11	10
Uranium oxide	1	2	4	8

The pigment for the anti-fouling of Paint No. 305 had the following composition, the percentages being those of the whole paint:

Iron oxide	13.5 per cent
Asbestine	5.25 "
Mercury oxide	3.75 "
Mercury oleate	5.00 "
Copper oxide	10.00 "
Mercury borosalicylate	2.5 "

The composition of the third coat of anti-fouling paint for Paint No. 306 was:

Zinc oxide	240 lb.
Silica	220 lb.
Mercury oxide	120 lb.
Mercury bichloride	10 lb.
Paris green	100 lb.
Ester gum liquid	84 gal.

The ester gum liquid referred to above consisted of:

Ester gum (neutral)	45 per cent
90-per-cent benzol	45 "
Spar varnish	10 "

The upper and lower portions of Panel No. 31 were not numbered.

In the diagrams of the panels, on the horizontal paint strips the number shown in boldface in the upper left corner is the paint number, and the Raritan Bay inspection grades are shown at the right hand end. The grades immediately to the left of these are those of the Charleston inspections. In the vertical paint strips (eight paints on each plate), the number in boldface is the paint number. Immediately below this are the grades for the Charleston inspections. In the bottom portion of these vertical spaces are to be found the grades of the Raritan Bay inspections. In any group of (usually four) figures for inspection at any one locality, the left figures represent the first inspection and the right figures, the second inspection. In these same groups, the upper figures are the inspections for corrosion and the lower figures (in italics) are for fouling. In the second Charleston inspection it frequently happened that only a portion of the paints of a panel were inspected, because the destruction of the coatings had gone too far.

The following grades were used:

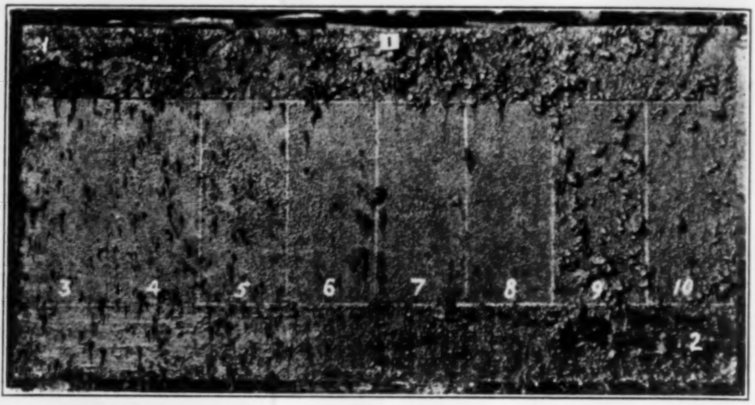
Corrosion: Best grade, 10 (least corrosion); poorest grade, 1.

Fouling: Best grade, 10 (least fouling); poorest grade, 1.

It was found that copper compounds alone or in mixtures with other poisons gave excellent anti-fouling properties in Raritan Bay, N. J., but were not as satisfactory as the mercury compounds, at Charleston, S. C., and as representing two marine conditions which are most common, these compounds were selected for the work of 1922, and other poisons omitted. Further tests are to be made with the same vehicles as used in 1921 or these modified slightly and in addition new compositions suggested to the committee.

Respectfully submitted on behalf of the sub-committee,

A. M. MUCKENFUSS,
Chairman.



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8 Raritan 3
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10 Charleston</td><td>6
9 Raritan 6
8</td></tr>
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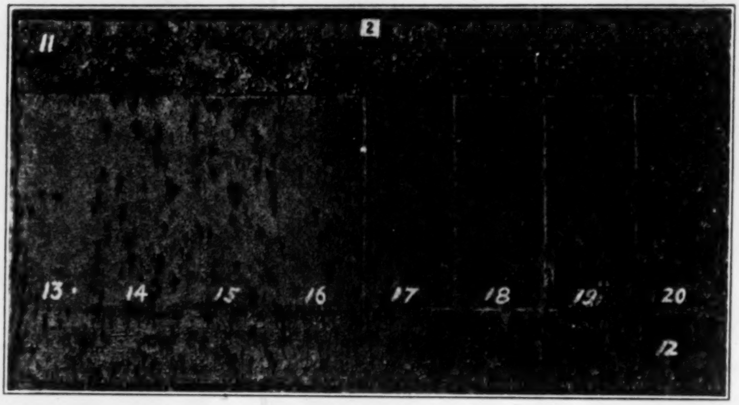
FIG. 1.—Panel No. 1. Photograph of Raritan Bay Panel, First Inspection.



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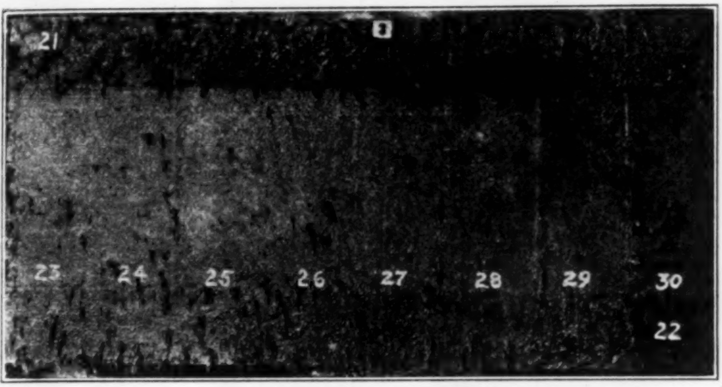
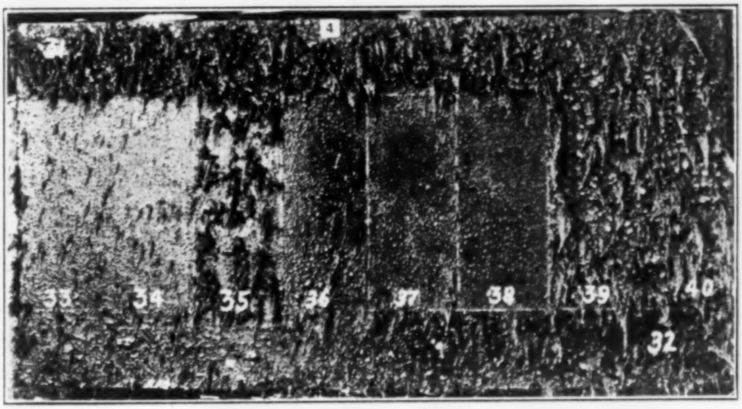
9 8</td><td>9 9
9 8</td><td>9 9
9 8</td><td>9 9
9 8</td><td>9 9
10 10</td><td>10 7
8 6</td><td>9 6
7 6</td></tr>
<tr><td>No. 12</td><td colspan="5">Norfolk No. 19</td><td>Charleston 7
3</td><td>8
8 Raritan 8
7</td></tr>
</table>

FIG. 2.—Panel No. 2. Photograph of Raritan Bay Panel, First Inspection.



<table>
<tr><td colspan="4">No. 21 (No second coat)</td><td colspan="2">9 Charleston 10
6 *9*</td><td colspan="2">3 Raritan 3
3 *3*</td></tr>
<tr><td>No. 23</td><td>No. 24</td><td>No. 25</td><td>No. 26</td><td>No. 27</td><td>No. 28</td><td>No. 29</td><td>No. 30</td></tr>
<tr><td>9 5
10 *4*</td><td>9 6
9 *5*</td><td>9 8
9 *6*</td><td>9 3
9 *3*</td><td>8 3
7 *3*</td><td>8 3
8 *3*</td><td>10 4
7 *2*</td><td>7 4
8 *2*</td></tr>
<tr><td>10 *A*</td><td>$12\frac{1}{2}$ *B*</td><td>14.3 *C*</td><td>$16\frac{2}{3}$ *D*</td><td>10 *E*</td><td>$12\frac{1}{2}$ *F*</td><td>11.1 *G*</td><td>11.1 *H*</td></tr>
<tr><td>9 9
9 *9*</td><td>10 9
9 *9*</td><td>9 9
9 *9*</td><td>10 9
9 *9*</td><td>9 9
9 *9*</td><td>9 9
10 *10*</td><td>10 10
8 *4*</td><td>9 7
7 *5*</td></tr>
<tr><td colspan="4">No. 22 Norfolk No. 19</td><td colspan="2">7 Charleston 3
9 *3*</td><td colspan="2">6 Raritan 6
4 *5*</td></tr>
</table>

FIG. 3.—Panel No. 3. Photograph of Raritan Bay Panel, First Inspection.



<table>
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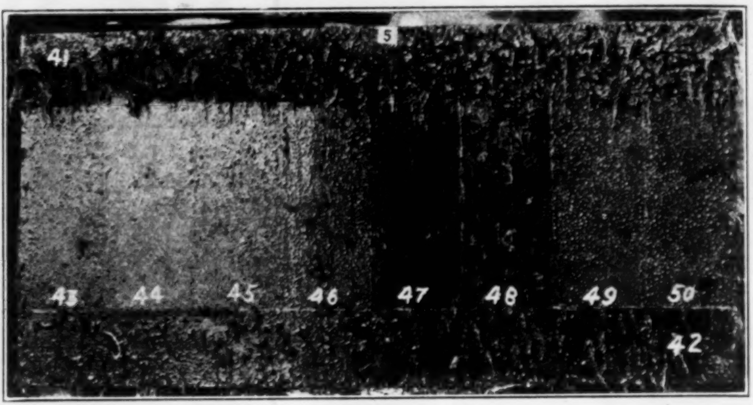
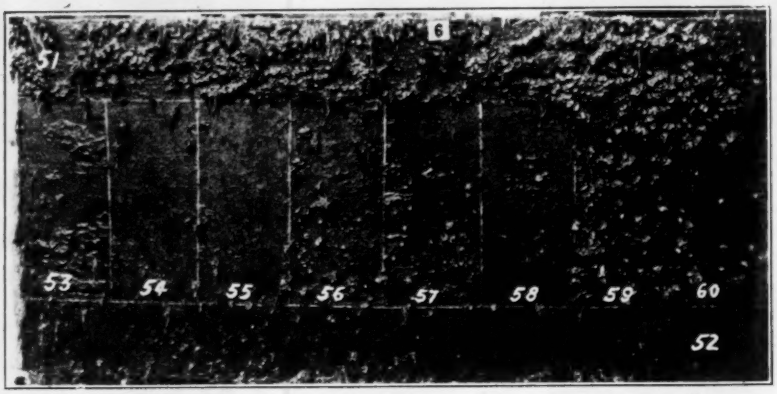
5</td><td colspan="2">3 Raritan 3
6 *6*</td></tr>
<tr><td>No. 33</td><td>No. 34</td><td>No. 35</td><td>No. 36</td><td>No. 37</td><td>No. 38</td><td>No. 39</td><td>No. 40</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>4
6</td><td>4
5</td></tr>
<tr><td>$12\frac{1}{2}$ *A*</td><td>20 *B*</td><td>(No second coat)</td><td>20 *D*</td><td>$16\frac{2}{3}$ *E*</td><td>$16\frac{2}{3}$ *F*</td><td>(No second coat)</td><td>$16\frac{2}{3}$ *H*</td></tr>
<tr><td>9 9
8 *8*</td><td>9 9
8 *8*</td><td>9 8
4 *7*</td><td>9 9
8 *8*</td><td>9 9
9 *8*</td><td>9 9
9 *9*</td><td>9 8
2 *3*</td><td>9 7
2 *6*</td></tr>
<tr><td colspan="4">No. 32 Norfolk No. 19</td><td colspan="2">Charleston 4
7</td><td colspan="2">4 Raritan 4
6 *5*</td></tr>
</table>

FIG. 4.—Panel No. 4. Photograph of Raritan Bay Panel, First Inspection.



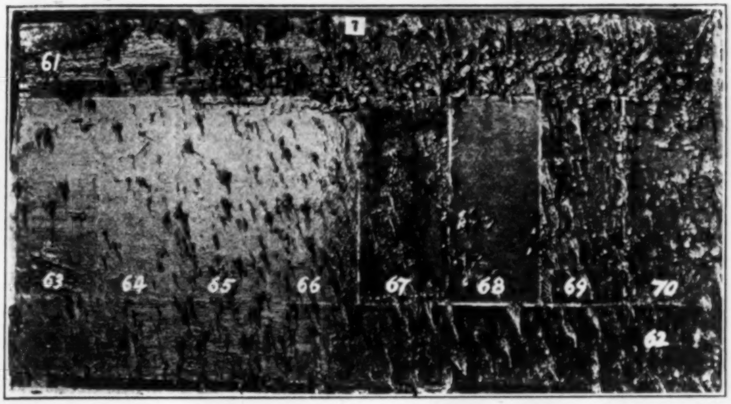
No. 41	(No second coat)					10 Charleston 7 3 2	3 Raritan 3 8 8
No. 43	No. 44	No. 45	No. 46	No. 47	No. 48	No. 49	No.
5 5 7 4	5 5 10 5	5 4 10 7	9 4 7 2	10 6 9 5	10 6 8 5	7 9	7 9
7½ E 7½ F 3.3 H	5 A 7½ F 3.3 H	5 B 7½ F 3.3 H	7½ E 2½ F 5 G	5 A 2½ F 5 G	5 B 2½ F 5 G	0.8 A 6.3 E 7½ F 3.3 H	0.8 B 6.3 E 7½ F 3.3 H
8 8 9 9	8 8 10 10	8 8 10 10	8 8 8 7	9 9 9 10	9 9 8 8	7 7 9 10	7 7 9 10
No. 42	Norfolk No. 19					8 Charleston 4 10 4	6 Raritan 6 7 6

Fig. 5.—Panel No. 5. Photograph of Raritan Bay Panel, First Inspection.



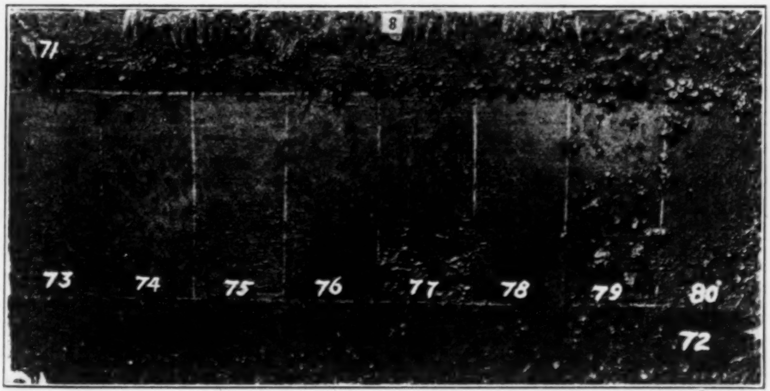
No. 51	(No second coat)					2 Charleston 9 8 8	2 Raritan 2 1 4
No. 53	No. 54	No. 55	No. 56	No. 57	No. 58	No. 59	No. 60
8 6 8.5 5	9 6 9 6	9 9 –	9 5 8 4	10 8 8 7	9 8 7 7	9 9 7 8	7 9 6 7
8⅓ A	8⅓ B	8⅓ C	8⅓ D	8⅓ E	8⅓ F	8⅓ G	8⅓ H
5 5 9 6	9 9 9 7	9 9 9 7	8 7 7 4	7 7 7 4	8 8 9 8	7 3 5 4	7 5 7 6
No. 52	Norfolk No. 19					10 Charleston 9 10 6	9 Raritan 9 8 8

Fig. 6.—Panel No. 6. Photograph of Raritan Bay Panel, First Inspection.



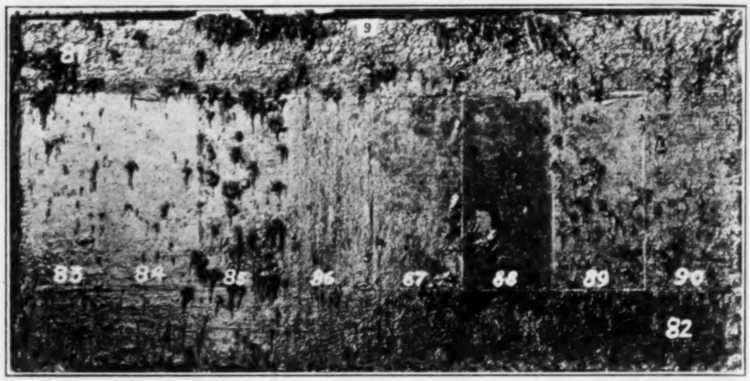
No. 61	(No second coat)				Charleston 7 3	3 8	Raritan 3 8
No. 63	No. 64	No. 65	No. 66	No. 67	No. 68	No. 69	No. 70
5 7	7 6	8 6		9 6	8 2	9 1	6 1
$8\frac{1}{3}$ A	$8\frac{1}{3}$ B	9.1 C	$12\frac{1}{2}$ D	$12\frac{1}{2}$ E	20 F	$10\frac{2}{3}$ C	(No second coat)
8 8 8 8	10 9 8 8	9 9 8 8	10 8 8 7	9 8 8 7	9 9 9 9	10 5 7 7	10 6 7 7
No. 62	Norfolk No. 19				Charleston 10 8	10 8	Raritan 8 7

'FIG. 7.—Panel No. 7. Photograph of Raritan Bay Panel, First Inspection.



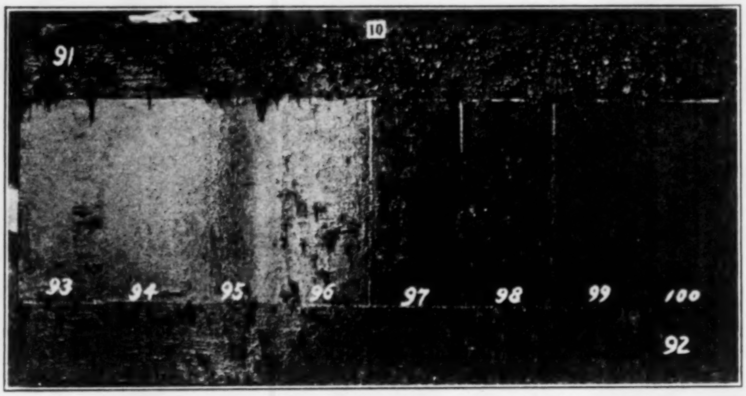
No. 71	(No second coat)					3 3	Raritan 3 3
No. 73	No. 74	No. 75	No. 76	No. 77	No. 78	No. 79	No. 80
10 A	$12\frac{1}{2}$ B	14.3 C	$16\frac{2}{3}$ D	10 E	$12\frac{1}{2}$ F	11.1 G	11.1 H
10 10 9 6	9 9 9 6	9 9 9 7	9 9 9 5	7 7 9 4	10 10 10 8	9 9 7 4	8 8 8 4
No. 72	Norfolk No. 19					10 6	Raritan 10 5

FIG. 8.—Panel No. 8. Photograph of Raritan Bay Panel, First Inspection.



<table>
<tr><td>No. 81</td><td colspan="4">(No second coat)</td><td colspan="2">Charleston 3
1</td><td colspan="2">4
6 Raritan 4
6</td></tr>
<tr><td>No. 83</td><td>No. 84</td><td>No. 85</td><td>No. 86</td><td>No. 87</td><td>No. 88</td><td>No. 89</td><td>No. 90</td></tr>
<tr><td>5
1</td><td>5
1</td><td>5
1</td><td>5
3</td><td>5
4</td><td>6
1</td><td>5
1</td><td>4
1</td></tr>
<tr><td>12½ A</td><td>20 B</td><td>(No second coat)</td><td>20 D</td><td>16⅔ E</td><td>16⅔ F</td><td>(No second coat)</td><td>16⅔ H</td></tr>
<tr><td>9 8
8 9</td><td>10 9
8 9</td><td>10 7
6 8</td><td>10 9
9 9</td><td>8 8
9 9</td><td>8 8
10 10</td><td>9 8
5 4</td><td>9 7
5 7</td></tr>
<tr><td>No. 82</td><td colspan="4">Norfolk No. 19</td><td colspan="2">Charleston 10
5</td><td colspan="2">10
8 Raritan 9
8</td></tr>
</table>

FIG. 9.—Panel No. 9. Photograph of Raritan Bay Panel, First Inspection.



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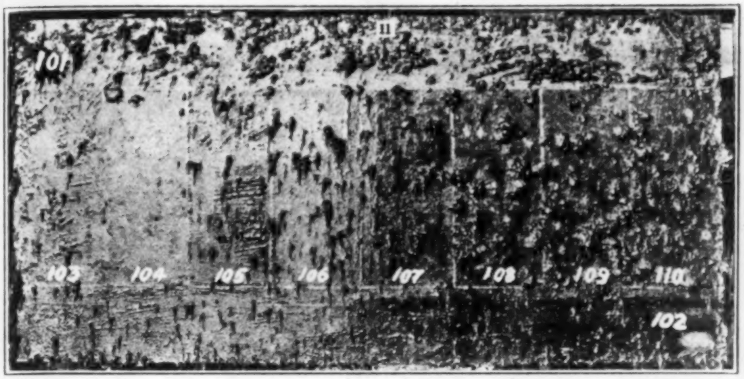
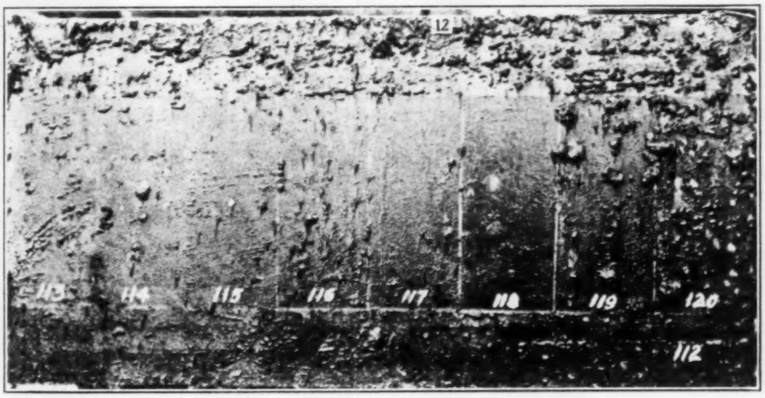
<tr><td>No. 91</td><td colspan="4">(No second coat)</td><td colspan="2"></td><td colspan="2">3
8 Raritan 2
8</td></tr>
<tr><td>No. 93</td><td>No. 94</td><td>No. 95</td><td>No. 96</td><td>No. 97</td><td>No. 98</td><td>No. 99</td><td>No. 100</td></tr>
<tr><td>7½ E
7½ F
3.3 H</td><td>5 A
7½ F
3.3 H</td><td>5 B
7½ F
3.3 H</td><td>7½ E
2½ F
5 G</td><td>5 A
2½ F
5 G</td><td>5 B
2½ F
5 G</td><td>0.8 A
6.3 E
7½ F
3.3 H</td><td>0.8 B
6.3 E
7½ F
3.3 H</td></tr>
<tr><td>8 8
10 9</td><td>10 10
10 10</td><td>10 10
10 10</td><td>10 8
8 7</td><td>9 9
8 9</td><td>8 8
8 9</td><td>10 10
10 10</td><td>10 9
10 10</td></tr>
<tr><td>No. 92</td><td colspan="4">Norfolk No. 19</td><td colspan="2"></td><td colspan="2">10
7 Raritan 9
8</td></tr>
</table>

FIG. 10.—Panel No. 10. Photograph of Raritan Bay Panel, First Inspection.



No. 101	(No second coat)			7 *7*	Charleston	6 *8* Raritan	4 *8*
No. 103	**No. 104**	**No. 105**	**No. 106**	**No. 107**	**No. 108**	**No. 109**	**No. 110**
9 *8*	7 *9*	9 *9*	9 *7*	8 *6*	8 *6*	8 *6*	8 *6*
8⅓ *A*	8⅓ *B*	[a]	8⅓ *D*	8⅓ *E*	8⅓ *F*	8⅓ *G*	8⅓ *H*
8 8 *9* *9*	9 9 *10* *9*	8 8 *9* *9*	10 8 *8* *9*	10 8 *7* *9*	10 8 *6* *9*	10 7 *6* *9*	7 6 *7* *9*
No. 102	Norfolk No. 19			10 *10*	Charleston	8 *9* Raritan	8 *9*

FIG. 11.—Panel No. 11. Photograph of Raritan Bay Panel, First Inspection.



No. 111	(No second coat)				Charleston 3 *1*	3 *6* Raritan	3 *7*
No. 113	**No. 114**	**No. 115**	**No. 116**	**No. 117**	**No. 118**	**No. 119**	**No. 120**
3 *3*	7 *7*	7 *7*	7 *2*	7 *2*	6 *4*	4 *3*	4 *3*
8⅓ *A*	8⅓ *B*	[a]	12½ *D*	12½ *E*	20 *F*	10⅔ *G*	(No second coat)
7 6 *9* *9*	8 8 *9* *9*	9 8 *9* *9*	10 8 *8* *7*	10 10 *9* *9*	10 10 *10* *10*	9 7 *7* *8*	6 4 *7* *7*
No. 112	Norfolk No. 19				Charleston 6 *5*	7 *9* Raritan	6 *8*

FIG. 12.—Panel No. 12. Photograph of Raritan Bay Panel, First Inspection.

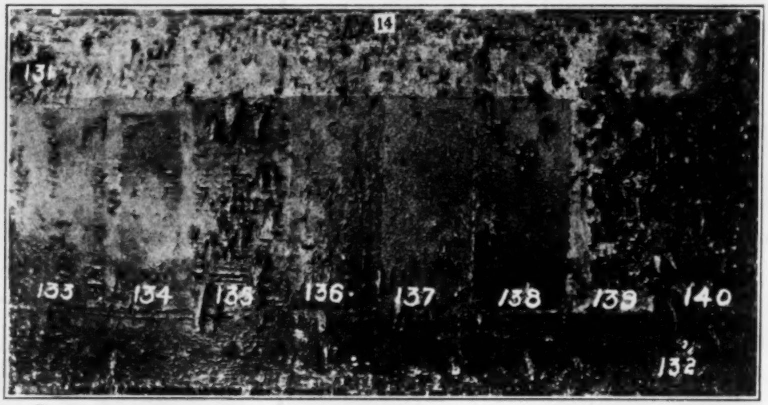
---

[a] Painted with Norfolk No. 19, because the original compositions coagulated.

121
123
124
125
126
127
128
129
130
122

No. 121						Charleston 4 4	5 4 Raritan 4 7
No. 123	**No. 124**	**No. 125**	**No. 126**	**No. 127**	**No. 128**	**No. 129**	**No. 130**
5 3	2 8	4 8	6 6	7 6	8 7	8 7	9 8
10 *A*	*a*	*a*	$16\frac{2}{3}$ *D*	10 *E*	$12\frac{1}{2}$ *F*	11.1 *G*	11.1 *H*
5 5 5 9	8 8 6 9	8 8 6 8	6 6 6 8	10 10 8 9	10 9 7 9	7 7 5 9	9 6 4 9
No. 122	Norfolk No. 19					Charleston 5 6	7 6 Raritan 7 7

FIG. 13.—Panel No. 13. Photograph of Charleston Panel, Second Inspection.

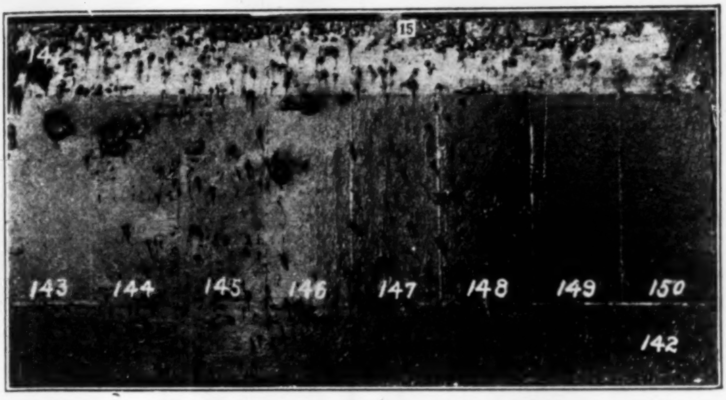


No. 131	(No second coat)						6 8 Raritan 4 5
No. 133	**No. 134**	**No. 135**	**No. 136**	**No. 137**	**No. 138**	**No. 139**	**No. 140**
$12\frac{1}{2}$ *A*	*a*	(No second coat)	20 *D*	$16\frac{2}{3}$ *E*	$16\frac{2}{3}$ *F*	(No second coat)	$16\frac{2}{3}$ *H*
8 7 9 9	8 6 9 8	6 4 7 5	9 8 9 7	10 9 9 7	10 9 9 9	5 5 7 5	6 4 6 5
No. 132	Norfolk No. 19						8 9 Raritan 6 6

FIG. 14.—Panel No. 14. Photograph of Raritan Bay Panel, First Inspection.

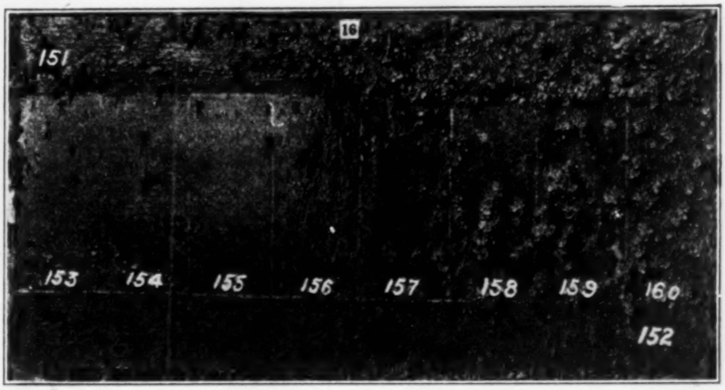
---

[a] Painted with Norfolk No. 19, because the original compositions coagulated.



No. 141	(No second coat)					Charleston 4 2	5 8 Raritan 4 7
No. 143	No. 144	No. 145	No. 146	No. 147	No. 148	No. 149	No. 150
6 4	5 4	5 4	4 3	5 5	7 6	7 4	9 3
7½ E 7½ F 3.3 H	[a]	[a]	7½ E 2½ F 5 G	5 A 2½ F 5 G	[a]	0.8 A 6.3 E 7½ F 3.3 H	0.8 B 6.3 E 7½ F 3.3 H
8 8 10 10	8 8 8 9	8 8 8 9	8 8 9 9	10 9 8 9	9 7 7 8	10 10 10 10	10 10 10 10
No. 142	Norfolk No. 19					Charleston 7 5	8 8 Raritan 7 7

FIG. 15.—Panel No. 15. Photograph of Raritan Bay Panel, First Inspection.

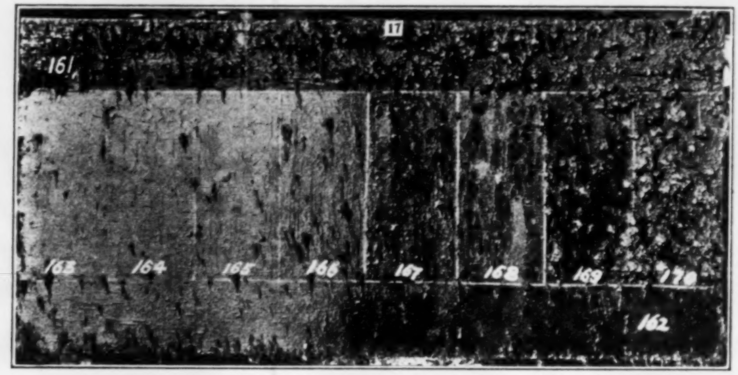


No. 151						Charleston 3 1	3 4 Raritan 3 4
No. 153	No. 154	No. 155	No. 156	No. 157	No. 158	No. 159	No. 160
7 4	7 6	7 7	5 3	6 3	7 3	7 3	4 5
8⅓ A	8⅓ B	[a]	8⅓ D	8⅓ E	8⅓ F	8⅓ G	8⅓ H
8 8 9 9	8 8 9 8	9 9 10 9	9 9 8 6	9 9 9 7	9 8 7 9	10 9 7 8	9 8 7 7
No. 152	Norfolk No. 19					Charleston 8 7	9 9 Raritan 9 8

FIG. 16.—Panel No. 16. Photograph of Raritan Bay Panel, First Inspection.

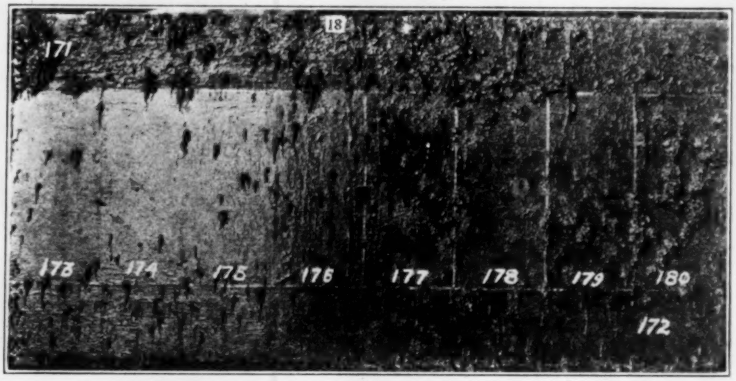
---

[a] Painted with Norfolk No. 19, because the original compositions coagulated.



No. 161						Charleston $\genfrac{}{}{0pt}{}{4}{7}$	$\genfrac{}{}{0pt}{}{6}{3}$ Raritan $\genfrac{}{}{0pt}{}{3}{4}$
No. 163	No. 164	No. 165	No. 166	No. 167	No. 168	No. 169	No. 170
8 7	9 8	9 8	8 4	8 3	8 3	8 5	8 5
$8\frac{1}{3}$ *A*	$8\frac{1}{3}$ *B*	*a*	$12\frac{1}{2}$ *D*	$12\frac{1}{2}$ *E*	20 *F*	$10\frac{2}{3}$ *G*	(No second coat)
9 8 9 9	9 8 9 9	9 8 9 9	10 9 8 7	10 10 9 9	9 9 8 10	10 7 7 7	9 6 6 6
No. 162	Norfolk No. 19					Charleston $\genfrac{}{}{0pt}{}{8}{7}$	$\genfrac{}{}{0pt}{}{9}{9}$ Raritan $\genfrac{}{}{0pt}{}{9}{8}$

FIG. 17.—Panel No. 17. Photograph of Raritan Bay Panel, First Inspection.

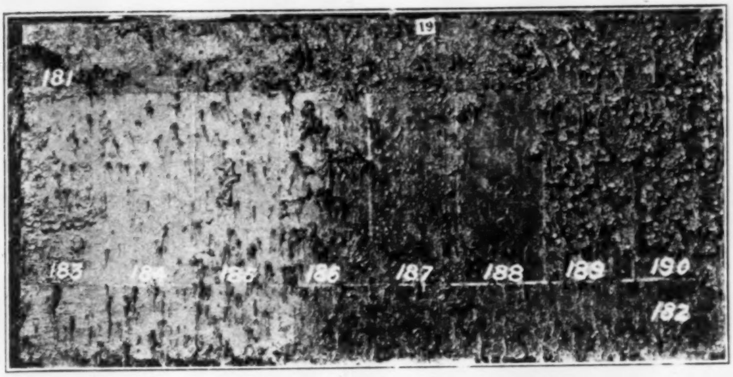


No. 171							$\genfrac{}{}{0pt}{}{2}{1}$ Raritan $\genfrac{}{}{0pt}{}{2}{4}$
No. 173	No. 174	No. 175	No. 176	No. 177	No. 178	No. 179	No. 180
10 *A*	*a*	*a*	$16\frac{2}{3}$ *D*	10 *E*	$12\frac{1}{2}$ *F*	11.1 *G*	11.1 *H*
8 8 8 8	9 9 9 9	10 10 8 9	9 9 7 6	10 9 8 6	9 9 8 9	10 9 7 5	9 5 3 7
No. 172	Norfolk No. 19						$\genfrac{}{}{0pt}{}{9}{7}$ Raritan $\genfrac{}{}{0pt}{}{9}{7}$

FIG. 18.—Panel No. 18. Photograph of Raritan Bay Panel, First Inspection.

---

[a] Painted with Norfolk No. 19, because the original compositions coagulated.

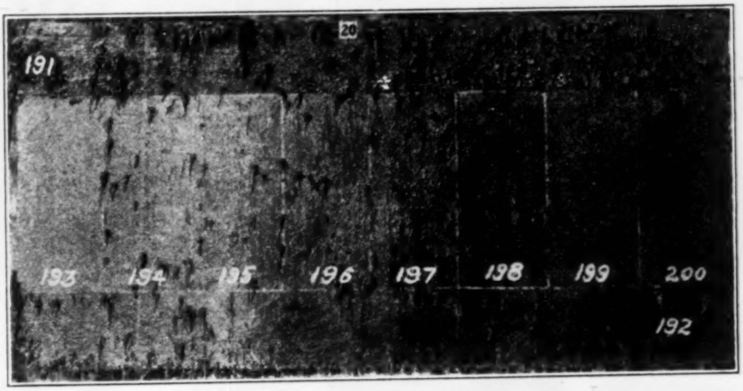


No. 181	6 *6*	Charleston	3 *7*	2 *4*	Raritan	2 *3*

No. 183	No. 184	No. 185	No. 186	No. 187	No. 188	No. 189	No. 190
7 3 *9 7*	10 8 *10 8*	8 3 *4 2*	10 9 *9 8*	10 7 *5 5*	10 6 *5 6*	10 5 *5 5*	10 5 *5 5*
$12\frac{1}{2}$ *A*	*a*	(No second coat)	20 *D*	$16\frac{2}{3}$ *E*	$16\frac{2}{3}$ *F*	(No second coat)	$16\frac{2}{3}$ *H*
10 5 *9 6*	9 9 *9 8*	8 8 *9 7*	7 7 *6 7*	9 9 *9 5*	8 8 *8 9*	8 3 *8 7*	8 3 *3 5*

No. 182	Norfolk No. 19	10 *10*	Charleston	9 *9*	9 *8*	Raritan	8 *4*

FIG. 19.—Panel No. 19. Photograph of Raritan Bay Panel, First Inspection.



No. 191	Charleston	4 *1*	6 *3*	Raritan	2 *3*

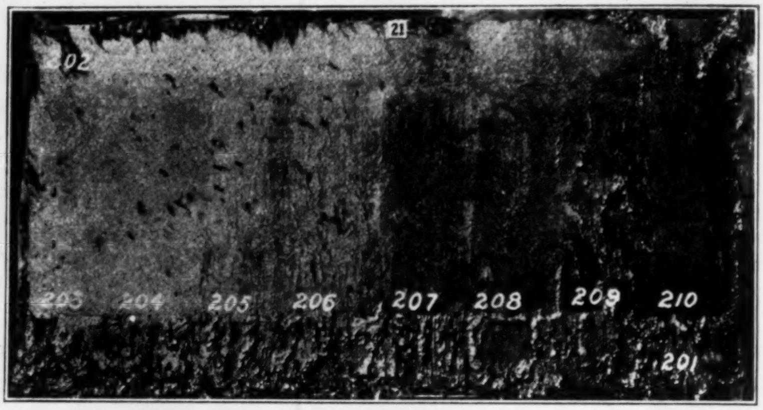
No. 193	No. 194	No. 195	No. 196	No. 197	No. 198	No. 199	No. 200
9 *8*	10 *9*	10 *10*	10 *4*	10 *4*	10 *10*	9 *8*	9 *8*
$7\frac{1}{2}$ *E* $7\frac{1}{2}$ *F* 3.3 *H*	*a*	*a*	$7\frac{1}{2}$ *E* $2\frac{1}{2}$ *F* 5 *G*	5 *A* $2\frac{1}{2}$ *F* 5 *G*	*a*	0.8 *A* 6.3 *E* $7\frac{1}{2}$ *F* 3.3 *H*	0.8 *B* 6.3 *E* $7\frac{1}{2}$ *F* 3.3 *H*
9 9 *10 10*	9 9 *9 8*	9 9 *9 9*	9 9 *7 8*	8 8 *6 6*	9 9 *9 9*	9 9 *10 10*	9 9 *10 10*

No. 192	Norfolk No. 19	Charleston	10 *9*	9 *9*	Raritan	9 *7*

FIG. 20.—Panel No. 20. Photograph of Raritan Bay Panel, First Inspection.

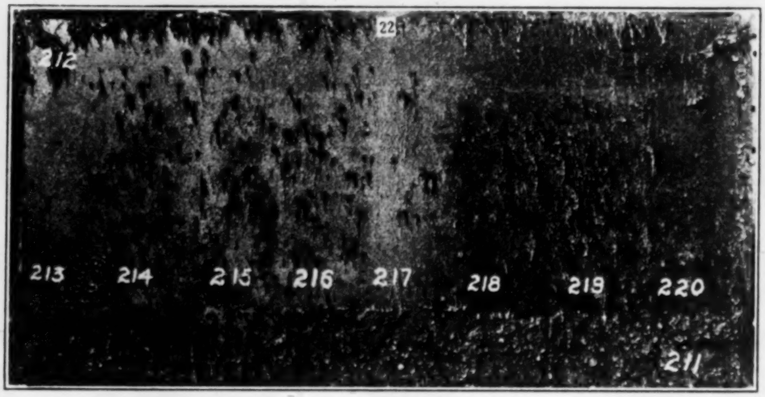
---

[a] Painted with Norfolk No. 19, because the original compositions coagulated.


21
202
203
204
205
206
207
208
209
210
201

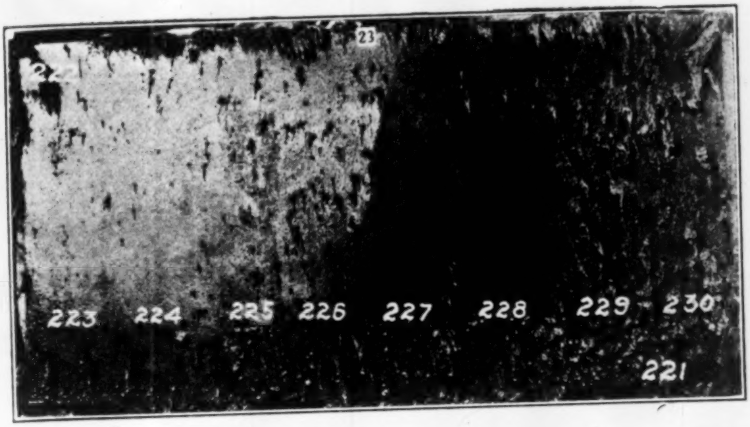
<table>
<tr><td>No. 202</td><td colspan="5">Norfolk No. 19</td><td colspan="2">10 10
Raritan
<i>9</i> <i>9</i></td></tr>
<tr><td>No. 203</td><td>No. 204</td><td>No. 205</td><td>No. 206</td><td>No. 207</td><td>No. 208</td><td>No. 209</td><td>No. 210</td></tr>
<tr><td>8⅓ <i>A</i></td><td>8⅓ <i>B</i></td><td>8⅓ <i>C</i></td><td>8⅓ <i>D</i></td><td>8⅓ <i>E</i></td><td>8⅓ <i>F</i></td><td>8⅓ <i>G</i></td><td>8⅓ <i>H</i></td></tr>
<tr><td>8 8
<i>9</i> <i>9</i></td><td>10 10
<i>9</i> <i>9</i></td><td>10 10
<i>9</i> <i>9</i></td><td>10 10
<i>8</i> <i>8</i></td><td>10 10
<i>10</i> <i>9</i></td><td>10 10
<i>10</i> <i>9</i></td><td>10 9
<i>7</i> <i>8</i></td><td>10 10
<i>10</i> <i>9</i></td></tr>
<tr><td>No. 201</td><td colspan="5">(No second coat)</td><td colspan="2">1 2
Raritan
<i>2</i> <i>4</i></td></tr>
</table>

FIG. 21.—Panel No. 21. Photograph of Raritan Bay Panel, First Inspection.


22
212
213
214
215
216
217
218
219
220
211

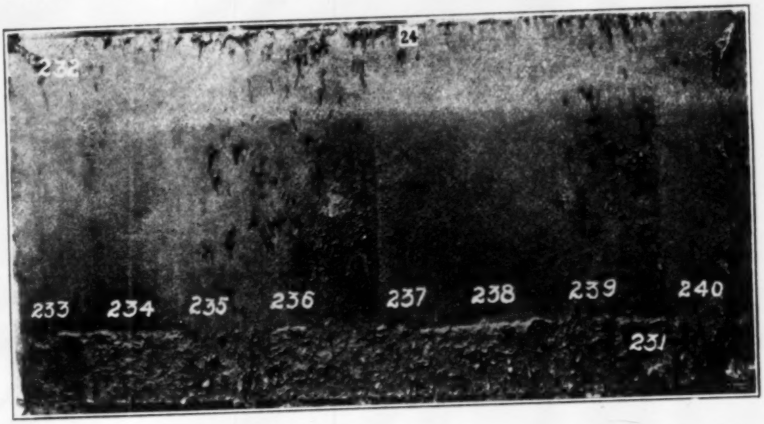
<table>
<tr><td>No. 212</td><td colspan="4">Norfolk No. 19</td><td colspan="2">9 9
Charleston
<i>9</i> <i>7</i></td><td colspan="2">10 10
Raritan
<i>9</i> <i>9</i></td></tr>
<tr><td>No. 213</td><td>No. 214</td><td>No. 215</td><td>No. 216</td><td>No. 217</td><td>No. 218</td><td>No. 219</td><td>No. 220</td></tr>
<tr><td>7 4
<i>9</i> <i>8</i></td><td>10 8
<i>10</i> <i>8</i></td><td>6 5
<i>7</i> <i>7</i></td><td>9 8
<i>9</i> <i>8</i></td><td>9 8
<i>7</i> <i>7</i></td><td>10 7
<i>5</i> <i>3</i></td><td>10 8
<i>6</i> <i>4</i></td><td>10 7
<i>5</i> <i>3</i></td></tr>
<tr><td>8⅓ <i>A</i></td><td>8⅓ <i>B</i></td><td>9.1 <i>C</i></td><td>12½ <i>D</i></td><td>12½ <i>E</i></td><td>20 <i>F</i></td><td>10⅔ <i>G</i></td><td>Norfolk
No. 19</td></tr>
<tr><td>9 8
<i>9</i> <i>9</i></td><td>10 10
<i>9</i> <i>9</i></td><td>10 10
<i>8</i> <i>8</i></td><td>10 10
<i>8</i> <i>8</i></td><td>10 10
<i>8.5</i> <i>8</i></td><td>10 9
<i>8</i> <i>7</i></td><td>10 9
<i>7</i> <i>7</i></td><td>10 10
<i>9</i> <i>9</i></td></tr>
<tr><td>No. 211</td><td colspan="4">(No second coat)</td><td colspan="2">3 6
Charleston
<i>5</i> <i>5</i></td><td colspan="2">5 5
Raritan
<i>7</i> <i>7</i></td></tr>
</table>

FIG. 22.—Panel No. 22. Photograph of Raritan Bay Panel, First Inspection.


23
223
224
225
226
227
228
229
230
221

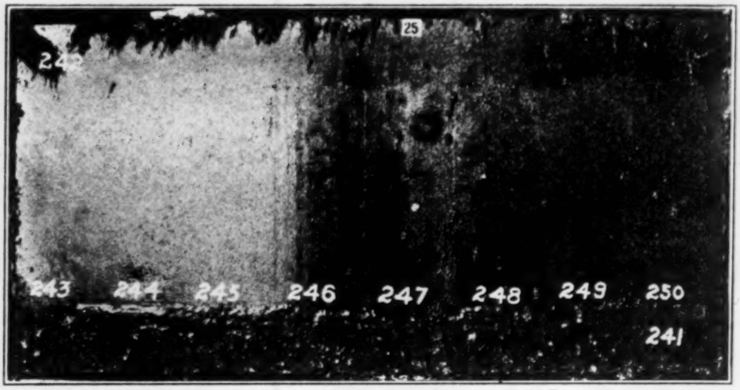
No. 222	Norfolk No. 19				9 9 Charleston		10 9 Raritan 10 9
No. 223	**No. 224**	**No. 225**	**No. 226**	**No. 227**	**No. 228**	**No. 229**	**No. 230**
7 *10*	8 *10*	5 *8*	8 *8*	9 *6*	9 *6*	10 *6*	9 *6*
10 *A*	12½ *B*	14.3 *C*	16⅔ *D*	10 *E*	12½ *F*	11.1 *G*	11.1 *H*
8 8 *10 10*	10 10 *9 10*	9 9 *8 9*	10 10 *7 8*	10 10 *9 9*	10 10 *10 10*	10 9 *6 7*	9 9 *6 8*
No. 221	(No second coat)					Charleston 10 *6*	7 *3* Raritan 3 *7*

FIG. 23.—Panel No. 23. Photograph of Raritan Bay Panel, First Inspection.


24
232
233
234
235
236
237
238
239
240
231

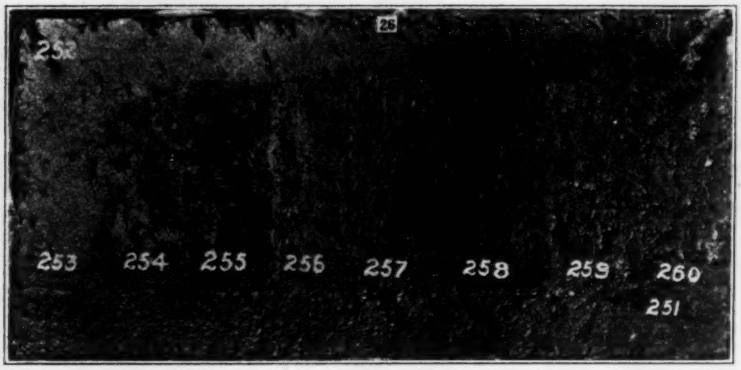
No. 232			Norfolk No. 19				10 *9* Raritan 10 *9*
No. 233	**No. 234.**	**No. 235**	**No. 236**	**No. 237**	**No. 238**	**No. 239**	**No. 240**
12½ *A*	20 *B*	Norfolk No. 19	20 *D*	16⅔ *E*	16⅔ *F*	Norfolk No. 19	16⅔ *H*
9 9 *10 10*	10 10 *10 10*	10 10 *9 8*	10 10 *8 9*	10 10 *10 10*	10 10 *10 10*	9 9 *8 5*	10 9 *9 9*
No. 231			(No second coat)				1 *7* Raritan 1 *6*

FIG. 24.—Panel No. 24. Photograph of Raritan Bay Panel, First Inspection.


25
242
243
244
245
246
247
248
249
250
241

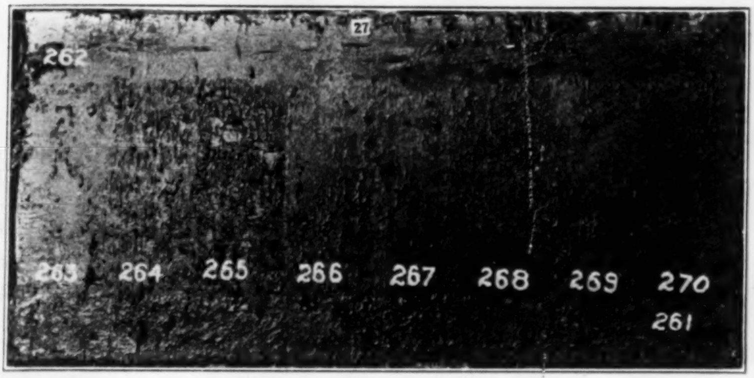
No. 242			Norfolk No. 19		10 *9*	Raritan	10 *9*
No. 243	**No. 244**	**No. 245**	**No. 246**	**No. 247**	**No. 248**	**No. 249**	**No. 250**
7.5 *E* 7.5 *F* 3.3 *H*	5 *A* 7.5 *F* 3.3 *H*	5 *B* 7.5 *F* 3.3 *H*	7.5 *E* 2.5 *F* 5 *G*	5 *A* 2.5 *F* 5 *G*	5 *B* 2.5 *F* 5 *G*	0.8 *A* 6.3 *E* 7.5 *F* 3.3 *H*	0.8 *B* 6.3 *E* 7.5 *F* 3.3 *H*
10 10 *10 10*	10 10 *10 10*	10 10 *10 10*	10 10 *9.5 9*	9 9 *9 9*	9 9 *9 9*	9 9 *10 10*	9 9 *10 9*
No. 241			(No second coat)		4 *7*	Raritan	4 *7*

FIG. 25.—Panel No. 25. Photograph of Raritan Bay Panel, First Inspection.


26
252
253
254
255
256
257
258
259
260
251

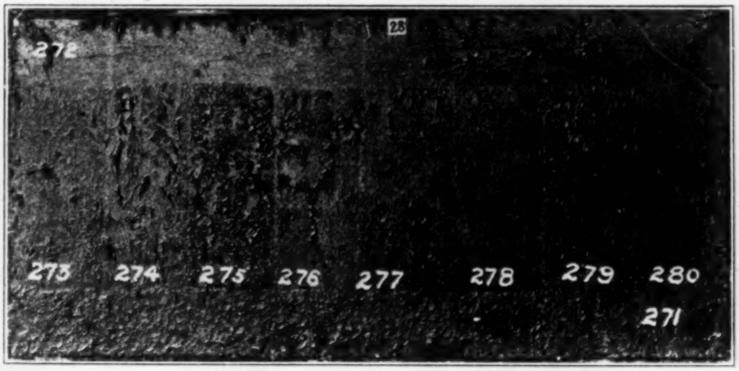
No. 252			Norfolk No. 19		9 *9*	Raritan	9 *9*
No. 253	**No. 254**	**No. 255**	**No. 256**	**No. 257**	**No. 258**	**No. 259**	**No. 260**
$8\frac{1}{3}$ *A*	$8\frac{1}{3}$ *B*	$8\frac{1}{3}$ *C*	$8\frac{1}{3}$ *D*	$8\frac{1}{3}$ *E*	$8\frac{1}{3}$ *F*	$8\frac{1}{3}$ *G*	$8\frac{1}{3}$ *H*
8 7 *9 9*	8 7 *8 9*	7 6 *8 7*	9 7 *8 8*	9 8 *9 9*	9 8 *9 9*	9 8 *8 8*	9 7 *8 8*
No. 251			(No second coat)		3 *9*	Raritan	3 *9*

FIG. 26.—Panel No. 26. Photograph of Raritan Bay Panel, First Inspection.


27
262
263
264
265
266
267
268
269
270
261

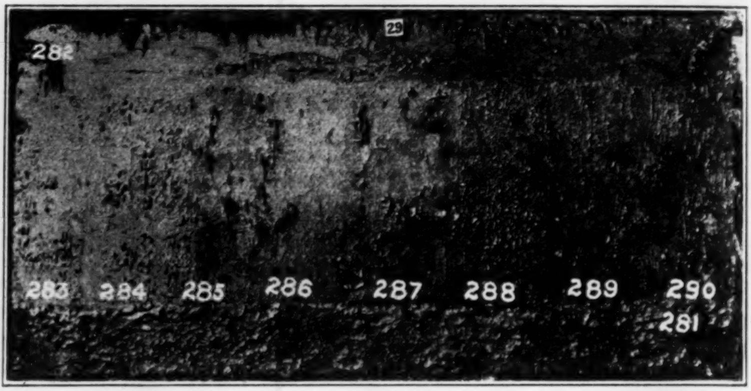
<table>
<tr><td colspan="2">No. 262</td><td colspan="10">Norfolk No. 19</td><td>6
9</td><td colspan="2">Raritan</td><td>6
9</td></tr>
<tr><td colspan="2">No. 263</td><td colspan="2">No. 264</td><td colspan="2">No. 265</td><td colspan="2">No. 266</td><td colspan="2">No. 267</td><td colspan="2">No. 268</td><td colspan="2">No. 269</td><td colspan="2">No. 270</td></tr>
<tr><td colspan="2">8⅓ A</td><td colspan="2">8⅓ B</td><td colspan="2">9.1 C</td><td colspan="2">12½ D</td><td colspan="2">12½ E</td><td colspan="2">20 F</td><td colspan="2">10⅔ G</td><td colspan="2">Norfolk
No. 19</td></tr>
<tr><td>7
9</td><td>7
8</td><td>6
9</td><td>6
7</td><td>5
9</td><td>5
7</td><td>8
9</td><td>8
9</td><td>8
9</td><td>8
8</td><td>8
9</td><td>6
7</td><td>7
9</td><td>7
8</td><td>7
9</td><td>7
8</td></tr>
<tr><td colspan="2">No. 261</td><td colspan="10">(No second coat)</td><td>4
7</td><td colspan="2">Raritan</td><td>4
7</td></tr>
</table>

FIG. 27.—Panel No. 27. Photograph of Raritan Bay Panel, First Inspection.


28
272
273
274
275
276
277
278
279
280
271

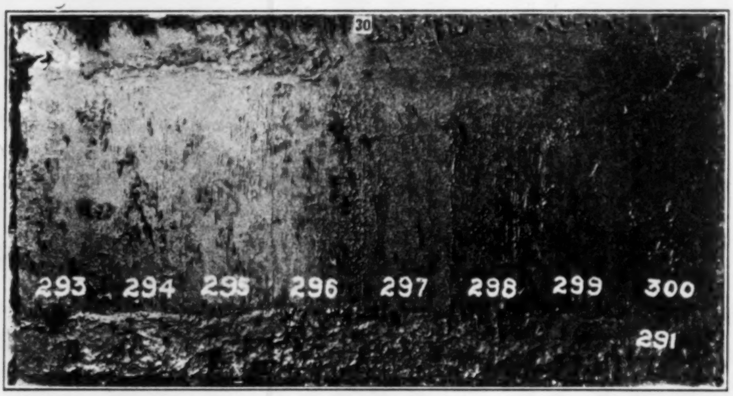
<table>
<tr><td colspan="2">No. 272</td><td colspan="8">Norfolk No. 19</td><td>Charleston</td><td>10
8</td><td>8
9</td><td colspan="2">Raritan</td><td>8
9</td></tr>
<tr><td colspan="2">No. 273</td><td colspan="2">No. 274</td><td colspan="2">No. 275</td><td colspan="2">No. 276</td><td colspan="2">No. 277</td><td colspan="2">No. 278</td><td colspan="2">No. 279</td><td colspan="2">No. 280</td></tr>
<tr><td></td><td>7
4</td><td></td><td>6
4</td><td></td><td>4
4</td><td></td><td>3
4</td><td></td><td>3
4</td><td></td><td>4
3</td><td></td><td>2
4</td><td></td><td>3
3</td></tr>
<tr><td colspan="2">10 A</td><td colspan="2">12½ B</td><td colspan="2">14.3 C</td><td colspan="2">16⅔ D</td><td colspan="2">10 E</td><td colspan="2">12½ F</td><td colspan="2">11.1 G</td><td colspan="2">11.1 H</td></tr>
<tr><td>7
9</td><td>6
9</td><td>6
9</td><td>6
9</td><td>3
9</td><td>3
9</td><td>5
8</td><td>5
9</td><td>6
9</td><td>5
9</td><td>7
9</td><td>6
9</td><td>7
8</td><td>7
9</td><td>7
8</td><td>5
9</td></tr>
<tr><td colspan="2">No. 271</td><td colspan="8">(No second coat)</td><td>Charleston</td><td>4
4</td><td colspan="3">Raritan</td><td>3
9</td></tr>
</table>

FIG. 28.—Panel No. 28. Photograph of Raritan Bay Panel, First Inspection.



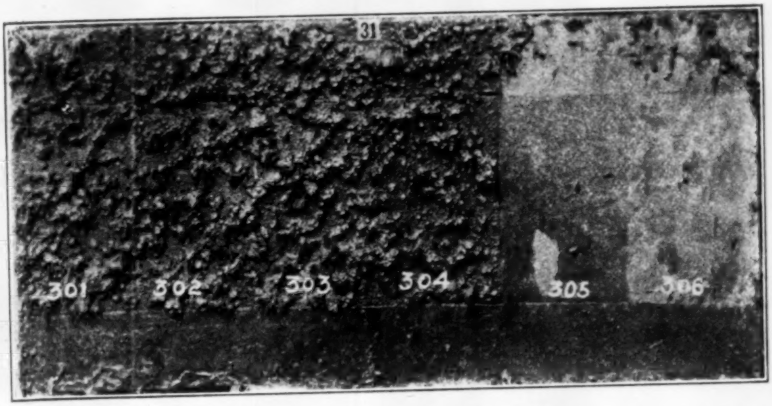
No. 282	Norfolk No. 19					Charleston 9 *7*	6 Raritan 6 *10* *8*
No. 283	**No. 284**	**No. 285**	**No. 286**	**No. 287**	**No. 288**	**No. 289**	**No. 290**
3 *5*	5 *1*	4 *3*	4 *3*	4 *3*	4 *4*	5 *4*	6 *2*
$12\frac{1}{2}$ *A*	20 *B*	Norfolk No. 19	20 *D*	$16\frac{2}{3}$ *E*	$16\frac{2}{3}$ *F*	Norfolk No. 19	$16\frac{2}{3}$ *H*
6 6 *10* *9*	6 6 *10* *9*	6 6 *8* *6*	6 6 *9* *8*	6 6 *9* *8*	6 6 *8* *7*	6 6 *9* *7*	6 6 *9* *7*
No. 281	(No second coat)					Charleston 1 *4*	4 Raritan 4 *9* *7*

FIG. 29.—Panel No. 29. Photograph of Raritan Bay Panel, First Inspection.



No. 292	Norfolk No. 19						5 Raritan 5 *9* *9*
No. 293	**No. 294**	**No. 295**	**No. 296**	**No. 297**	**No. 298**	**No. 299**	**No. 300**
7.5 *E* 7.5 *F* 3.3 *H*	5 *A* 7.5 *F* 3.3 *H*	5 *B* 7.5 *F* 3.3 *H*	7.5 *E* 2.5 *F* 5 *G*	5 *A* 2.5 *F* 5 *G*	5 *B* 2.5 *F* 5 *G*	0.8 *A* 6.3 *E* 7.5 *F* 3.3 *H*	0.8 *B* 6.3 *E* 7.5 *F* 3.3 *H*
6 6 *9* *6*	6 6 *9* *9*	7 7 *10* *10*	8 7 *7* *6*	9 7 *8* *7*	9 7 *8* *7*	7 7 *9* *8*	7 7 *9* *8*
No. 291	(No second coat)						3 Raritan 3 *8* *8*

FIG. 30.—Panel No. 30. Photograph of Raritan Bay Panel, First Inspection.



(No second coat)			Charleston 3 8	3 4 Raritan 3 4	Charleston 3 8 | 9 9 Raritan 6 7
No. 301	**No. 302**	**No. 303**	**No. 304**	**No. 305**	**No. 306**
2 9	2 9	2 9	2 9	2 9	2 9
9 5 4 5	4 5	4 5	4 5	9 10 9 10	7 10 7 9
Norfolk No. 19			Charleston 6 10	8 9 Raritan 8 8	Charleston 6 10 | 10 10 Raritan 9.5 9
Left					Right

Fig. 31.—Panel No. 31. Photograph of Raritan Bay Panel, First Inspection.

REPORT OF COMMITTEE D-2
ON
PETROLEUM PRODUCTS AND LUBRICANTS.

Committee D-2 has held four meetings during the past year. The membership has been increased to a total of 63 consisting of 32 non-producers and 31 producers. Additional sub-committees on Gas Oil and on Organic Acidity have been created.

The committee recommends for adoption as standard, without amendment, the present Tentative Method of Test for Melting Point of Paraffin Wax (D 87 - 21 T).[1]

The committee recommends for adoption as standard the Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 - 21 T)[2] with the following amendment:

Section 3 (f).—After the second sentence, add a sentence to read as follows:

> "The first application of the test flame shall be made at a temperature at least 30° F. below the actual flash point."

The committee recommends the following revisions in the present Standard Methods of Testing Lubricants (Viscosity) (D 47 - 21)[3] for publication as tentative:

Section 6 (a).—Change the third sentence to read as follows by the addition of the italicized figures:

> "At the bottom of the standard oil tube is a small outlet tube through which the oil to be tested flows into a receiving flask, Fig. 3, whose capacity *at 20° C. (68° F.)* to a mark on its neck is 60 (±0.15) cc."

Section 6 (b).—Add the following dimension to the table included in Section 6 (*b*):

> "Depth of cylindrical part of container, minimum, cm............8.8."

Add a new section to read as follows:

> "The Saybolt Standard Universal Viscosimeter shall not be used for times of flow less than 32 seconds."

Attention is called to the recommendation of Sub-Committee V on Viscosity that the inside diameter of the outlet tube of the Saybolt Standard Universal Viscosimeter be fixed by an equation of the form suggested in the report for 1921, and that the mean A value should be 0.00216. During the coming year the committee intends to adopt tolerances for normal *A* value of 0.00216, and invites criticisms and suggestions.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 638 (1921).

[2] *Ibid.*, p. 655.

[3] 1921 Book of A.S.T.M. Standards.

The committee recommends the revision of the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 21 T) as shown in the report of Sub-Committee XVI on Cloud and Pour Test, and further recommends that with these revisions the method be continued as tentative.

The committee is presenting for publication as tentative the following additional methods of test:

Tentative Method of Test for Melting Point of Petrolatum.
Tentative Method of Test for Sulfur in Petroleum Oils Heavier Than Illuminating Oil.
Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline.
Tentative Method of Analysis of Grease.

The committee recommends that, contingent upon the acceptance by the Society of the Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline, the present Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Petroleum Products (D 89 – 21 T)[1] be withdrawn.

The committee recommends the use of the term "A.P.I." in designating gravity based on the 141.5 modulus.

Appended hereto are reports of Sub-Committees I, III, IV, V, VI, VII, XI, XII, XVI and XVII.

This report, and the methods of test recommended for adoption as standard and submission as tentative standards, have been submitted to letter ballot of the committee, which consists of 63 members. 38 ballots have been returned, and 25 members have refrained from voting.

	AFFIRMCTIVE.	NEGATIVE.	NOT VOTING.
General Report	30	0	8
Adoption as Standard of the Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 21 T)	36	0	2
Adoption as Standard of the Tentative Method of Test for Melting Point of Paraffin Wax (D 87 – 21 T)	34	0	4
Proposed Revision of the Standard Methods of Testing Lubricants (Viscosity) (D 47 – 21)	35	1	2
Proposed Revision of the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 21 T)	32	1	5

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[1] *Proceedings*, Am Soc. Test. Mats. Vol. 21, p. 643 (1921).

	AFFIRMATIVE.	NEGATIVE.	NOT VOTING.
Proposed Tentative Method of Test for Melting Point of Petrolatum	24	3	11
Proposed Tentative Method of Analysis of Grease	29	1	8
Proposed Tentative Method of Test for Sulfur in Petroleum Oils Heavier Than Illuminating Oil	31	0	7
Proposed Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline	33	0	5
Withdrawal of Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Petroleum Products (D 89 - 21 T)	29	3	6

Respectfully submitted on behalf of the committee,

C. P. VAN GUNDY,
Chairman.

K. G. MACKENZIE,
Secretary.

EDITORIAL NOTE.

The Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester amended as indicated in this report and the Tentative Method of Test for Melting Point of Paraffin Wax were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1922.

The proposed revisions of the Standard Methods of Testing Lubricants (Specific Gravity, Free Acid, Carbon Residue, Viscosity) were accepted for publication as tentative and appear on page 991.

The proposed revisions of the Tentative Method of Test for Cloud and Pour Points of Petroleum Products referred to in this report were accepted. The method of test as thus revised appears on page 781.

The proposed Tentative Method of Test for Melting Point of Petrolatum, the proposed Tentative Method of Analysis of Grease, the proposed Tentative Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil and the proposed Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline were accepted for publication as tentative and appear on pages 766–780.

The withdrawal of the Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Petroleum Products was approved.

For use in obtaining the melting points of petrolatum the report of this sub-committee last year proposed a special thermometer having a solid glass extension below the mercury bulb. Objection has been made to the construction on two accounts: First, the solid piece of glass might introduce the element of lag which we were trying to overcome by leaving the mercury bulb uncovered, and second, it required the stocking of one other special thermometer. The second objection can be overcome by recommending the use of the "A.S.T.M. Paraffin Wax Melting Point Thermometer" adopted last year as part of the Tentative Method of Test for Melting Point of Paraffin Wax (D 87 – 21 T). Briefly, this is an etched-stem mercurial thermometer 368 mm. long, having a range of 80 to 160° F. graduated in 0.2° F. with cylindrical bulb of a diameter not greater than the stem and 28 mm. long, to be used at 3⅛-in. immersion. The objection to lag is overcome, or at least reduced to less than experimental error, by coating as directed in the proposed tentative method.

In order to test out the new method, a set of four samples each was sent by the chairman of the sub-committee to each of its members. These samples were tested and reported upon, the results being recorded in Table I. The reports have brought out two interesting points: First, the low variations in results of individual operators, as well as the small extreme differences between highest and lowest values on the same sample by different observers, and second, the fact that three of the operators reporting did not have the prescribed thermometers, but did use those having cylindrical bulbs of different lengths and for immersions varying from ¾-in. to total.

Recent studies by Sub-Committee XVI in cloud and pour tests indicated that oils submitted to a temperature of 175° F. gave more uniform solidifying points as shown by pour test than when heated to lower temperatures. These facts give assurance that the method makes use of right principles.

The thermometer used by Laboratory No. 1 as shown in the accompanying table was 533 mm. long, range 80 to 150° F., graduated 0.1° F., cylindrical bulb 22 mm., scaled for total immersion, stem correction not applied. Those used by Laboratory No. 5 were of a type having a range 80 to 150° F., graduated 0.25° F., cylindrical bulb 9 to 11 mm. long, scaled for ¾-in. immersion. The readings on Sample *D* by Laboratory No. 5 are consistent among themselves but are so much higher than the average that they are omitted from the final figures. Either they are reported incorrectly or the temperatures do not represent the exact time of the first drop, judging from the very good checks on Sample *D* by the other Laboratories. The figures for Sample *B* from the report of laboratory No. 3 are also omitted. Each sample of the series was large enough to more than fill all of the small samples sent out and the two that were blended were heated to a high enough temperature to insure thorough melting and mixing. Either the melting point of Sample *B* is incorrectly reported or Samples *A* and *B* sent to Laboratory No. 3 were identical. With these two figures out, the extreme differences between the highest and lowest values are: Samples *A*, 4.3°; *B*, 4.15°; *C*, 3.5°; *D*, 1.3° F.; the average melting point for the four samples being *A*, 130.11°; *B*, 125.94°; *C*, 122.28°; *D*, 109.92° F. The extreme differences, it will be noted, are between one set of consistent results but

TABLE I.—RESULTS OF INVESTIGATION ON MELTING POINT OF PETROLATUM.

Laboratory.	Petrolatum.	Melting Point.					Thermometer.				
		1st Test.	2d Test.	3d Test.	Average.	By Routine Method.	Length of Stem mm.	Length of Bulb, mm.	Immersion.	Graduation.	Range.
No. 1..	A	129.8	131.3	129.5	130.2	130	533	22	Total	0.1° F.	80–150° F.
	B	125.5	125.6	125.8	125.6	125	...	..	.....	......	....
	C	122.9	121.9	122.3	122.4	121	...	..	.....	......	....
	D	109.8	109.5	109.9	109.7	108	...	..	.....	......	....
No. 2..	A	128.4	127.6	128.6	128.2	.....	...	..	.....	......	....
	B	124.2	124.0	123.8	124.0	.....	...	..	.....	......	....
	C	120.2	120.4	120.4	120.3	.....	...	..	.....	......	....
	D	110.0	109.8	108.4	109.1	.....	...	..	.....	......	....
No. 3..	A	.....	.....	.....	132.0	.....					
	B	.....	.....	.....	132.0	.....	350	25	.....	......	20–400° F.
	C	.....	.....	.....	123.8	.....	300	25	3-in.	......	0–150° C.
	D	.....	.....	.....	109.4	.....					
No. 4..	A	130.5	130.3	132.7	131.2	133.3	368	28	3 1/8-in.	0.2° F.	80–160° F.
	B	129.2	127.4	127.0	127.9	127.5	...	..	.....	......	....
	C	122.0	122.3	122.8	122.4	122.3	...	..	.....	......	....
	D	111.4	109.6	110.2	110.4	109.2	...	...	.....	......	....
No. 5..	A	132.75	132.25	127.00	132.5	.....	...	9–11	3/4-in.	0.25° F.	80–150° F.
	B	129.25	127.50	128.75	128.15	.....	...	..	.....	......	....
	C	123.15	123.35	.....	123.25	.....	...	..	.....	......	....
	D	114.75	114.00	114.75	114.50	.....	...	..	.....	......	....
No. 6..	A	128.8	128.0	128.8	128.5	.....	...	..	.....	......	....
	B	124.6	125.0	124.2	124.6	.....	...	..	.....	......	....
	C	121.2	121.8	121.6	121.6	.....	...	..	.....	......	....
	D	109.4	109.0	110.6	109.7	.....	...	..	.....	......	....
No. 7..	A	130.4	130.8	131.8	131.0	.....	...	..	.....	......	....
	B	127.6	127.0	126.0	126.8	.....	...	..	.....	......	....
	C	123.2	122.6	122.5	122.8	.....	...	..	.....	......	....
	D	110.1	110.4	110.8	110.4	.....	...	..	.....	......	....

Average A, 7 laboratories, 130.11
" B, 6 laboratories, 125.94
" C, 7 laboratories, 122.28
" D, 6 laboratories, 109.92

uniformly lower than the average and another set uniformly higher than the others and the average.

Of the four samples submitted, *A* and *C* were straight runs, *B* a mixture of equal parts *A* and *C*, and *D* a mixture of 30 per cent Sample *C* and 70 per cent of a filtered cylinder oil of poor pour test.

The criticism that the method is slow is justified but this can be tolerated in a referee method so long as the results, particularly on such a product as petrolatum, are reproducible. Operators using this method will soon learn where the time can be shortened, but for work in close decisions, the method should be exactly followed.

The sub-committee herewith[1] presents for consideration as a tentative standard a method for obtaining the melting point of petrolatum.

Respectfully submitted on behalf of the sub-committee,

FLORUS R. BAXTER,
Chairman.

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[1] See p. 766.—ED.

REPORT OF SUB-COMMITTEE III ON PARAFFIN WAX.

The sub-committee submits for information the following method of determination of oil and moisture in wax and upon which the sub-committee invites criticism and suggestions:

OIL AND MOISTURE IN PARAFFIN WAX.

Apparatus.—

Wax Press.—A lever press with a pressing surface $5\frac{1}{2}$ to $5\frac{5}{8}$ in. in diameter and capable of producing a pressure of 1000 lb. per sq. in. shall be used.

Balance.—A balance accurate to ± 1 mg. shall be used.

Linen.—Two pieces of linen cut to fit the wax press cup. (*Note:* Grade of linen to be specified, Silesia suggested.)

Blotters.—Circular blotters to fit press plate.

Food chopper or nutmeg grater.

Minor accessories, container for wax and thermometer.

Preparation of Samples.—Solid wax should be freed from all foreign substances such as dirt, sticks, etc., before sampling. Care should be taken, however, not to wipe from the surface any oil and moisture which may be present. Remove portions of the wax from the surface and interior, so as to fairly represent the quantity to be examined. The wax is then pulverized in a food chopper or in any other convenient manner, and quartered for the final sample.

Procedure.—The finely powdered wax is then placed in a pan and cooled in a refrigerator until the wax has reached a temperature of 60° F. The wax is then removed from the refrigerator to a room maintained at 60° F. Two linen cloths are weighed; then 30 to 35 g. of the sample are placed on top of them, and the total weight determined. The wax, etc., are removed from the balance pan and the lower disk of linen placed over the wax. The sample which has been thus prepared is placed between blotters, two[1] on each side.

The wax is then pressed for ten minutes under a pressure of 1000 lb. per sq. in. The wax, blotters, etc., are removed from the press, and blotters removed from the wax, and then linens and wax weighed.

The loss in weight represents oil and moisture.

$$\begin{array}{c}\text{Percentage Oil}\\ \text{and Moisture}\end{array} = \frac{\begin{array}{c}\text{Weight of cloths and wax before pressing} - \text{Weight of}\\ \text{cloths and wax after pressing}\end{array}}{\text{Weight of wax before pressing.}} \times 100.$$

Respectfully submitted on behalf of the sub-committee,

C. K. FRANCIS,
Chairman.

REPORT OF SUB-COMMITTEE IV ON GREASE.

The sub-committee presents for publication as tentative the proposed Tentative Method of Analysis of Grease as appended hereto.[2]

Respectfully submitted on behalf of the sub-committee,

G. CASH,
Chairman.

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[1] Three if wax contains considerable oil.

[2] See p. 768.—ED.

REPORT OF SUB-COMMITTEE V ON VISCOSITY.

The sub-committee recommends that the table given in its report for 1921[1] be revised as follows:

> "The following table shows the approximate relation between time Saybolt Universal and time Saybolt Furol, and is given merely as a guide in determining which instrument to use, in accordance with the instruction of Section 4 of the Saybolt Furol test.[2] It should not be used for viscosimeter conversions.

Time Furol, seconds.	Time Ratio, Universal-Furol.	Time Furol, seconds.	Time Ratio, Universal-Furol.
25	8.69	50	9.68
30	9.08	75	9.86
35	9.33	100	9.94
40	9.49	150	9.99
		200 and over	10.00

The sub-committee recommends the following tentative revisions of the present Standard Methods of Testing Lubricants (Viscosity) (D 47–21):[3]

Section 6 (a).—Change the third sentence to read as follows by the addition of the italicized figures:

> "At the bottom of the standard oil tube is a small outlet tube through which the oil to be tested flows into a receiving flask, Fig. 3, whose capacity *at 20° C. (68° F.)* to a mark on its neck is 60 (±0.15) cc."

Section 6 (b).—Add the following dimension to the table included in Section 6 (*b*):

> "Depth of cylindrical part of container, minimum, cm. . . . . 8.8."

Add a new section to read as follows:

> "The Saybolt Standard Universal Viscosimeter shall not be used for times of flow less than 32 seconds."

In the 1921 report the sub-committee presented an equation connecting absolute viscosity with time of flow, as the most permanent and desirable method of standardizing a viscosimeter, since either a calibrating liquid or an instrument is subject to change or destruction.

In continuing the work of standardizing the Saybolt Universal viscosimeter, it was necessary to take the following steps:

(*a*) To agree on the viscosity, Saybolt Universal, of a calibrating liquid at a given temperature.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 362 (1921).

[2] *Ibid.*, p. 642.

[3] 1921 Book of A.S.T.M. Standards.

(*b*) To agree on the kinematic viscosity of this liquid at the same temperature.

(*c*) To calculate the *A* value from a *B* value of 1.80 and the values adopted under (*a*) and (*b*). The equation then becomes

$$\frac{\text{absolute viscosity}}{\text{density}} = A\,t - \frac{1.80}{t}$$

where $A = 0.00216$ and $B = 1.80$.

Samples were sent to 23 laboratories to determine the Saybolt Standard Universal Viscosity at 100° F. Leaving out a few scattering results not within the range of 200 to 212, the average value was found to be 207 seconds. The next step was to agree upon the kinematic viscosity (the absolute viscosity divided by the density at the same temperature) and for this purpose the same sample was sent to three laboratories supplied with the Bingham viscosimeter, it being believed that this is the most accurate instrument for determining absolute viscosity. The following table shows absolute viscosities, from which the kinematic viscosities are obtained by dividing by the density, 0.872.

LABORATORY.	ABSOLUTE VISCOSITY.	KINEMATIC VISCOSITY.	*A* VALUE.
United Gas Improvement Co., Instrument No. 1	0.3831	0.4388	0.002162
United Gas Improvement Co., Instrument No. 2	0.3838	0.4396	0.002166
Bureau of Standards	0.3830	0.4387	0.002161
Lafayette College	0.3847	0.4407	0.002171

The last column was calculated from the equation given above, with *t* equal to 207, the Saybolt viscosity at 100° F. of the oil in question. The average *A* value is 0.002165, but since the highest value of absolute viscosity was obtained at the latest date, and there was other evidence of a slight increase in the viscosity of the oil with time, it seemed best to adopt the value of 0.00216 as the *A* value for a normal instrument. Since the *A* value fixes the inside diameter of the outlet tube, this dimension should be omitted as soon as suitable tolerances for the *A* value can be determined.

Respectfully submitted on behalf of the sub-committee,

W. H. HERSCHEL,
Chairman.

REPORT OF SUB-COMMITTEE VI ON COLOR.

Sub-Committee VI has been engaged in the study of the various instruments used by the petroleum industry for determining color. The work has been divided into two groups: (1) color determination of naphthas, kerosenes, etc., (2) color determination of lubricating oils.

Color determinations of naphthas, kerosenes, etc., are commercially made on a Lovibond Tintometer or Saybolt Chromometer. The former instrument is seldom used in America and owing to the difficulty of obtaining it, it was not considered by the sub-committee. In view of the general use of the Saybolt Chromometer, the sub-committee felt that this instrument should be adopted for use by the Society. A thorough investigation of the Saybolt Chromometer shows many points which require consideration and action before the instrument can be put into satisfactory shape for use in a standard method.

Some of the points under discussion are as follows:

1. *Head.*—Several members of the sub-committee suggested that the head be improved by introducing refinements in the manufacture such as (1) a positive position for the prisms and (2) diaphragms to eliminate the shadows and make the reading more positive and accurate.

2. *Position of tubes.*—In the present instrument the position of tubes is not sufficiently fixed, and it is possible for tubes to be misaligned with openings in the head. Construction should be changed so as to make the position positive in all cases.

3. *Diameter of tubes.*—At the present time no limits exist for the internal diameter of tubes. Experimental work has shown definitely that the internal diameter of the tube will affect the readings considerably.

4. *Mirror.*—Question has been raised as to suitability of the mirror as a light reflector, due to the fact that the mirror reflects color as well as light. It has been suggested that this difficulty be overcome by use of suitable means to obtain diffused light.

5. *Source of light.*—The original directions with the Saybolt Chromometer call for use with northern daylight exposure. In view of the wide variations existing in daylight, the sub-committee is considering the use of an artificial daylight lamp.

These points are brought to your attention with the hope that members of Committee D-2 and others will offer suggestions and criticisms which will aid the sub-committee in its work.

Color determinations of lubricating oils are commercially made using the Union Colorimeter with the National Petroleum Association color standards. At the annual meeting of the Society in 1921, the Atlantic Colorimeter, developed in the laboratories of The Atlantic Refining Co., was presented to the Society. During the past year, a similar instrument called the Tag-Robinson Colorimeter has been developed. The last two named instruments are of the same type, measuring the depth of oil necessary to match certain definite standards. Both instruments can be calibrated to read N.P.A. values, although each instrument has its own special scale. These instruments are entirely satisfactory for plant control work as more definite differentiation can be made than on the Union Colorimeter. It would be undesirable to determine color on lubricating oil from a commercial point of view on either of the new instruments on any basis other than the N.P.A. values. Experimental work on the Union Colorimeter shows the need of a container of more definite size than an ordinary 4-oz. sample bottle. The sub-committee has cooperated in the work of determining the N.P.A. value on the Tag-Robinson instrument. In this work a 35-mm. internal diameter clear, colorless glass cylinder was used in place of the ordinary sample bottle.

In order that suggestions and criticisms will be made, the sub-committee is giving in the Appendix a method for Color of Refined Oil by Saybolt Chromometer, Table I showing comparison of Saybolt Color and Potassium Bichromate solutions and common descriptive terms, and Table II showing comparison of N.P.A. colors and Potassium Bichromate solutions as worked out in the Bureau of Standards laboratory.

Respectfully submitted on behalf of the sub-committee,

T. G. DELBRIDGE,
Chairman.

APPENDIX.

Color of Refined Oil by Saybolt Chromometer.

1. *Scope.*—The color of all refined oils (naphthas, kerosenes, etc.) shall be determined by means of the Saybolt Chromometer.

2. *Apparatus.*—The Saybolt Chromometer shall consist of two glass tubes ⅝ in. in inside diameter. One glass tube, 20 in. long, shall be permanently closed at the

Table I.—Comparison of Saybolt Color and Potassium Bichromate Solutions.

Saybolt Chromometer.		Color Shade.	Common Descriptive Term.	Potassium Bichromate, mg. per liter.	
Number of Disks.	Height of Oil, in.			[a]	[b]
One	20	Plus 25			
"	18	" 24			
"	16	" 23			
"	14	" 22			
"	12	" 21	Water White.....	4.8	5.1
"	10.75	" 20			
"	9.50	" 19			
"	8.25	" 18			
"	7.25	" 17			
"	6.25	" 16	Prime White.....	12.0	
Two	10.50	" 15			
"	9.75	" 14			
"	9.00	" 13			
"	8.25	" 12			
"	7.75	" 11			
"	7.25	" 10			
"	6.75	" 9	....	....	19.0
"	6.50	" 8			
"	6.25	" 7			
"	6.00	" 6			
"	5.75	" 5			
"	5.50	" 4			
"	5.25	" 3			
"	5.00	" 2			
"	4.75	" 1			
"	4.50	0	Standard White..	....	30.0
"	4.25	Minus 1			
"	4.00	" 2			
"	3.75	" 3			
"	3.625	" 4			
"	3.50	" 5			
"	3.375	" 6			
"	3.25	" 7			
"	3.125	" 8			
"	3.00	" 9			
"	2.875	" 10			
"	2.75	" 11			
"	2.625	" 12			
"	2.50	" 13			
"	2.375	" 14			
"	2.25	" 15			
"	2.125	" 16			

[a] These values are from *Bulletin No. 5*, Committee on Standardization of Petroleum Specifications.

[b] These values are from The Atlantic Refining Co. experimental work. Water at 60° F.

bottom with a colorless, plano glass disk. This glass tube shall be graduated in ⅛-in. divisions numbered in inches, and shall be provided with a small pet-cock located at the bottom of the tube for the purpose of draining the same. The other tube, 19 in. long, shall be open at both ends, one end being mounted in a suitable metal collar which holds the color standards.[1] The tubes shall be mounted parallel to each other in a vertical position. Light shall be provided by means of a reflecting mirror set at a 45-deg. angle, so arranged that the reflected light shall pass through suitable openings and through the glass tubes in parallel rays. The instrument shall be provided with a suitable optical head consisting of prisms and eyepiece. The prisms shall be arranged so that the light rays from the tubes shall be deflected to a central aperture which is viewed by the eyepiece. The arrangement shall be such as to provide a circular field of vision, the two halves of which are illuminated by the light transmitted by the sample and the color standard, respectively. Light shall be supplied by a suitable daylight lamp so arranged as to avoid a glare on the reflecting mirror. The color standards shall consist of suitable glass disks.

3. *Procedure.*—The Saybolt Chromometer shall be assembled and light source adjusted so that no glare or shadows shall be shown on the reflecting mirror. Light from all other sources shall be excluded. The oil tube shall be cleaned by rinsing with some of the oil to be tested, care being taken to allow it to drain thoroughly. Two standard disks shall be placed in position in the open tube. The pet-cock on the oil tube shall be closed and oil tube shall be filled to a height of 10.5 in. The color shall be observed through the eyepiece. Measurement shall be made using two disks in cases where the oil is darker and one disk in cases where the oil is lighter. After determining the number of disks to be used and with the proper number in place, the oil tube shall, if necessary, be filled until the color of the oil is decidedly darker than the standard. Oil shall be drawn off slowly by means of the pet-cock until the oil is slightly darker than the standard. The oil shall then be drawn down to the first reached height corresponding to a standard color shade as shown in Table I. If the color of the oil observed through the eyepiece is still darker than the standard, the oil shall be drawn down to the next height equal to a color shade and examined again. This operation shall be continued until the oil and standard colors match or show questionable differences. The column of oil shall be lowered one shade more and if the oil is unmistakably lighter than the standard, the previous color shade shall be recorded as the Saybolt Chromometer color.

Examples.—

	No. 1	No. 2
Oil darker......	using 1 disk at 16 in.	using 2 disks at 4.5 in.
Oil darker......	" 1 " " 14 "	" 2 " " 4.25 "
Oil questionable.	" 1 " " 12 "	" 2 " " 4.0 "
Oil lighter......	" 1 " " 10.75 "	" 2 " " 3.75 "
Color is.........	plus 21	minus 2

4. *Accuracy.*—Variations due to different operators should not exceed one color shade.

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[1] The mounting of this tube shall be such as to give equal length to both tubes.

TABLE II.—COMPARISON OF N. P. A. COLORS AND POTASSIUM BICHROMATE SOLUTIONS.

N. P. A. COLOR, MID-CONTINENT OIL AND PARAFFIN OILS.	SOLVENT.	POTASSIUM BICHROMATE PER 100 CC. OF SOLVENT, G.
1.0	water	0.0057
1.5	water	0.0147
2.0	water	0.0453
2.5	water	0.0830
3.0	water	0.1361
3.5	60 per cent H_2SO_4	0.2910
4.0	60 " "	0.4500
4.5	60 " "	0.5330
5.0	60 " "	0.6810
6.0	75 " "	0.6800

Prepared by Dr. W. H. Herschel, Bureau of Standards.

Solutions.—H_2SO_4 is poured into the water and allowed to cool before the Potassium Bichromate is added. The acids are 60 and 75 per cent of the 95-per-cent acid by volume, or more accurately 110.2 and 138.0 g. of H_2SO_4 per 100 cc. of acid. The solutions change color on standing and must be matched immediately and discarded.

SUB-COMMITTEE VII ON SULFUR DETERMINATION AND DIFFERENTIATION.

The sub-committee has prepared a Tentative Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil. This method of test is appended hereto[1] and the sub-committee recommends that it be accepted for publication as tentative.

Respectfully submitted on behalf of the sub-committee,

E. W. Dean,
Chairman.

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[1] See p. 777 —Ed

REPORT OF SUB-COMMITTEE XI ON EMULSIFICATION.

The present and former committees have reviewed the different tests proposed to determine the emulsification of oils. These tests may be classified and summarized as follows:

1. *Shaker Tests:* Stratford; Bryan; Cosden.

In all modifications there are too many non-controllable variables and other bad features to permit the test to be suitable for referee work.

2. *Stirring Tests* (mechanical): Emulsibility; Demulsibility; Navy; Philip; Herschel.

The Philip Test is a British test so similar to the Navy Test that it has not been considered. The R.E. and Herschel consider demulsibility only. Vacuum, Navy (and Philip) consider emulsibility.

3. *Steaming Tests:* Conradson; Vacuum; R.E.

The Navy, Herschel, Conradson, Vacuum, and R.E. have been subjected to comparative studies over a considerable period of time by quite a number of different laboratories. In going through the accumulated files of this committee, the following notes and comments have been compiled:

> (NOTE.—The discussions and arguments of the authors of the various tests are omitted, largely since these have already been presented before the committee; but all of the following comments have been taken from reports and correspondence, with a sincere effort on the part of the committee to play no favorites.)

All five of these methods will group oils into three classes:

1. Oils which are undoubtedly very bad.
2. Oils which are undoubtedly very good.
3. Oils which are neither good nor bad.

A large number of present-day lubricating oils are in Class 3, and hence the desire is to get a test which will differentiate oils of this class as well as taking care of those in Class 1 and Class 2.

Ideals to be sought for in the "best" test are:

1. Ease of operation.
2. Simplicity and availability of apparatus.
3. Negligible personal equation.
4. Reproducibility of results by different operators.
5. Sample of small size.
6. Short time required.
7. Result to be an indication of the value and behavior of the oil in practice.

It is claimed: "A demulsibility-emulsibility test must not only give an intelligent idea of the possible emulsifying qualities of the oil in service, but also an dea of its degree of refinement." This is answered by: (1) "This confuses the logical function of the emulsion test in the hands of the inspection and testing laboratory with the use a refiner puts the test to in gaging and controlling plant operation. *The user is concerned with the behavior of the oil in use—not its history.*" (2) "The Vacuum and Conradson tests attempt to do this but are subject to personal interpretation based on much experience, and we are considering purely reproducible referee tests."

CONRADSON.

Favorable.—

(The only records in our files in favor of the Conradson Method are written by Dr. Conradson himself. They are not repeated here since he has already put them before the committee.)

Unfavorable.—

The quantity of oil required is too large.

Necessity of describing quantity and appearance of the three resulting layers.

The need of experience to interpret results properly.

Good oils not classified by results of different operators.

Demulsibility value practically the same for a fair oil and for a good oil.

Requires 24 hours for results.

HERSCHEL. (See also Navy.)

Favorable.—

In our opinion the Herschel test is the best of the severa' methods proposed.

This is an emulsion test, while the Vacuum and Navy (with soda) are sludging tests.

Dr. Herschel has presented the various merits and arguments in favor of his test.

Unfavorable.—

Does not give concordant results with high viscosity oils.

Demulsibility factor is sometimes misleading in that one sample may separate completely in a shorter time than another, and yet have a smaller demulsibility factor.

Inability of some operators to check themselves.

NAVY. (See also Herschel.)

Favorable.—

One member favors use of reagents, saying that steam may contain salt and soda ash due to foaming or priming.

Shows up poor oils, results of different operators agreeing fairly well with such oils.

Normal caustic soda shows up presence of sulfonates (poor refining) as no other test will.

Navy differs from Herschel in that relative quantities of oil and water used are not in same proportions and that salt and NaOH solutions are used.

Infinitely superior to the Herschel interpretation.

The definite numerical results given in other tests are often misleading.

Unfavorable.—

Five members say no different from Herschel, except for volumes, methods of reading and reagents used.

Five members opposed to reagents.

On good and medium oils, the results of different operators vary widely.

A centrifugal separating effect combined with mixing, which cannot be controlled.

Twenty-four hours to obtain results.

Four tests to each oil.

Apparatus is expensive.

Necessary to adjust speed for different oils.

Difficult to observe when *all* oil is settled out, since at the end the rate of settling is very slow.

Personal interpretation of the term "a slight cuff."

Not satisfactory on oils having a viscosity higher than 50 seconds at 210° F., Saybolt.

R. E. TEST.

Favorable.—

In general, classifies oils same as Herschel.

Shows difference in oils not shown by the Conradson.

Blends of cylinder oils and steam test Solar Red of 280 seconds viscosity at 100° F., are difficult to test to get concordant results by Herschel, etc., methods, easy for R.E.

Results are obtained within twenty minutes.

Samples are small.

As purely a measure of emulsification, the R.E. Value is considered a good method of measurement.

Gives results that are more uniform on a greater range of oils than any other test.

Unfavorable.—

Use of two different temperatures.

Requires too much care and attention.

Conditions and appearance of water, emulsion and oil layers are not reported.

Use of a numerical scale.

Length of time necessary to complete test.

A small difference of time in readings of an oil of fairly high R.E. Values show even greater differences in R.E. Values. (Remedied by proposed method of reporting.)

Two temperatures to control, and one to adjust.

Requires undivided attention of operator.

The higher the viscosity, the lower the R.E. values, other things being equal. (Comment on fact that viscosity plays a part and is not considered: "An emulsification-demulsification test should either indicate the difficulty with which the *oil under consideration*, compared to other oils of the same class and used for the same purpose, goes into an emulsion, or what is believed to be the same thing, the ease with which the formed emulsion separates.")

Difficult to maintain required steaming temperature with oils of low viscosities (up to 60 seconds, 100° F., Saybolt).

Difficult to tell just when to stop steaming.

TABLE I.—RESULTS OF EMULSIFICATION TESTS OF PETROLEUM OILS.

CONRADSON DEMULSIBILITY, VOLUMES AT THE END OF 1 HR. DEMULSIBILITY = OIL, CC.—WATER, PER CENT.

Laboratories		Oil 1*A*	Oil 2*A*	Oil 3*A*	Oil 4*A*	Oil 1*T*	Oil 2*T*	Oil 3*T*	Oil 4*T*	Oil 1*V*	Oil 2*V*	Oil 3*V*	Oil 4*V*	Oil 1*C*	Oil 2*C*	Oil 3*C*	Oil 4*C*
No. 1	Water, cc.	2	0	0	38	45	45	10	27	0	0	0	0	42	43	32	22
	Emul., cc.	48	42	56	0	11	11	39	38	54	50	52	0	0	0	12	20
	Oil, cc.	94	100	86	104	96	97	93	94	92	96	92	102	104	102	104	100
	Conradson.	93.75	98	86	99.25	95+	96.5	92.6	94	91.4	95.8	91.6	99.8	99+	99+	99+	99
	Demulsibil.	..	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..
No. 2	Water, cc.	10	3	3	44	..	..	..	..	..	..	..	..	43	46	52	50
	Emul., cc.	44	46	51	0	..	..	..	..	..	..	..	..	0	0	0	8
	Oil, cc.	90	100	95	100	..	..	..	..	..	..	..	..	100	100	102	100
	Conradson.	87	100	94	100	..	..	..	..	..	..	..	..	100	100	100	100
	Demulsibil.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
No. 3	Water, cc.	2	4	3	46	0	8	10	2	42	4	38	38	50	48	12	2
	Emul., cc.	72	49	60	0	54	44	44	60	98	76	112	0	0	0	40	52
	Oil, cc.	78	99	89	104	98	98	98	88	16	78	6	100	100	100	100	100
	Conradson.	78	99	89	100	98	98	98	88	..	78	..	100	100	100	100	100
	Demulsibil.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
No. 5	Water, cc.	8	0	0	46	5	2	3	0	0	0	0	46	45	41	40	43
	Emul., cc.	52	48	58	0	45	48	49	50	58	58	62	0	0	0	5	0
	Oil, cc.	88	100	92	100	100	100	97	100	92	92	88	100	100	100	96	100
	Conradson.	88	100	92	100	100	100	97	100	92	92	88	100	100	100	96	100
	Demulsibil.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
No. 6	Water, cc.	5	41	10	..	..	..	..	..	..	..	..	..	..	..	..	..
	Emul., cc.	50	11.5	44	..	..	..	..	..	..	..	..	..	..	..	..	..
	Oil, cc.	98	100	99	..	..	..	..	..	..	..	..	..	..	..	..	..
	Conradson.	96.5	99.5	98.75	..	..	..	..	..	..	..	..	..	..	..	..	..
	Demulsibil.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
No. 8	Water, cc.	..	..	..	..	..	..	..	..	0	0	0	67	..	..	..	..
	Emul., cc.	..	..	..	..	..	..	..	..	65	82	80	0	..	..	..	..
	Oil, cc.	..	..	..	..	..	..	..	..	85	70	75	103	..	..	..	..
	Conradson.	..	..	..	..	..	..	..	..	85	70	75	100	..	..	..	..
	Demulsibil.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
No. 10	Water, cc.	16	4	2	43	5	3	5	1	40	41	0	40	42	42	44	41
	Emu., cc.	36	42	49	0	43	45	37	48	48.6	27	83	1	0	1	3	6
	Oil, cc.	97	103	98	107	100	100	100	100	71	82	65	106	105	103	103	103
	Conradson.	97	100	98	100	100	100	100	100	71	82	65	100	100	100	100	100
	Demulsibil.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

RESISTANCE TO EMULSIFICATION—R.E.

Laboratories.	Oil 1*A*	Oil 2*A*	Oil 3*A*	Oil 4*A*	Oil 1*T*	Oil 2*T*	Oil 3*T*	Oil 4*T*	Oil 1*V*	Oil 2*V*	Oil 3*V*	Oil 4*V*	Oil 1*C*	Oil 2*C*	Oil 3*C*	Oil 4*C*
No. 1	10	16	19	100	45	3.75	20	3.75	5.4	5.5	5.0	100	100	100	40	40
No. 2	9.1	25	11.8	100	..	..	..	..	..	..	..	..	100	100	16.7	18.2
No. 3	6.6 5.9	20 ..	11.1 11.8	100 ..	12.5 ..	11.1 ..	7.7 ..	5 ..	4.25 ..	4.25 ..	3.25 ..	100 ..	100 ..	100 ..	22.2 ..	25 ..
No. 4	..	..	..	..	25	28	18.0	11.8	..	..	..	..	..	..	..	..
No. 5	5	18.2	13.3	200	7.0	18.2	4.2	4.7	4.5	4.2	3.5	28.5	200	100	6.6	10.0
No. 6	6.9	16.7	14.3	100	40	25	14.3	11.8	4.5	4.5	4.25	66.7	200	66.7	25.0	25
No. 7	7.7	22.2	10.5	100	33	25	15.4	7.7	5.0	3.75	4.4	66.7	100+	100	18.2	18.2
No. 8	..	..	..	..	..	..	..	..	6.6	5.4	4.5	100	..	..	..	..
No. 9	5.0	14.3	9.1	66.7	18.2	20	14.3	11.1	66.7	9.5	2.9	1.2	100	66.7	13.3	..
No. 10	8.9	18.3	14.7	200	25.0	8.3	12.5	10.2	5.5	4.6	4.0	100	200	58.3	14.8	33.3

TABLE I.—RESULTS OF EMULSIFICATION TESTS OF PETROLEUM OILS (*Continued*).

HERSCHEL DEMULSIBILITY.

Laboratories.	Oil 1*A*	Oil 2*A*	Oil 3*A*	Oil 4*A*	Oil 1*T*	Oil 2*T*	Oil 3*T*	Oil 4*T*	Oil 1*V*	Oil 2*V*	Oil 3*V*	Oil 4*V*	Oil 1*C*	Oil 2*C*	Oil 3*C*	Oil 4*C*
No. 1	N.T.	170	180	1200	82.8	60	29.16	27.9	0	24	12	1200	1200	1200	1080	1200
No. 2	N.T.	60	73	1080 960	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	900 ..	600 540	840 ..	450 ..
No. 3	N.T. 1200	65 ..	65 ..	1200 ..	190 ..	86 ..	53 ..	36 ..	2 ..	2 ..	5 ..	1200 ..	1200 ..	540 N.T.	107 ..	192 ..
No. 4	..	..	..	..	1200	1200	1200	1200	..	..	..	..	..	..	..	..
No. 5	18.6	180	132	1200	84	132	56	14.4	3.3	1	1	228	1200	1200	40	24
No. 8	..	..	..	..	..	..	..	..	2	2	6.5	1200	..	..	..	..
No. 9	N.T.	56.7	48	480	69.1	43.1	27.3	24.0	280	45.8	10.9	40	600	400	77.5	..
No. 10	25	114	74	1200	129	39	83	35	7	27	6	900	1200	600	78	1180

NAVY NAOH, PERCENTAGE EMULSION REMAINING AT DESIGNATED TIME.

Laboratories.		Oil 1*A*	Oil 2*A*	Oil 3*A*	Oil 4*A*	Oil 1*T*	Oil 2*T*	Oil 3*T*	Oil 4*T*	Oil 1*V*	Oil 2*V*	Oil 3*V*	Oil 4*V*	Oil 1*C*	Oil 2*C*	Oil 3*C*	Oil 4*C*
No. 1	0.5 hr.	98.75	58.75	77.5	0	56.9	61.9	74.4	88.1	98.75	98.75	96.25	40	0	0	97.5	97.5
	1 hr.	97.5	0	32.5	....	50	53.12	61.9	74.4	97.5	96.25	91.25	0	....	....	25	93.7
	4 hr.	50	....	0	....	0	0	0	2.75	95	90	80	....	....	....	0	73.75
	24 hr.	16.25	....	....	....	....	....	....	1.25	90	73.75	60	....	....	....	....	61.25
No. 2	0.5 hr.	100	13.3	72.5	0	....	....	....	....	....	....	....	....	0	0	92.4	91
	1 hr.	100	0	47	....	....	....	....	....	....	....	....	....	....	....	80	84.5
	4 hr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	24 hr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
No. 3	0.5 hr.	100	31	66	0	60	60	75	77.5	100	95	95	18	0	0	90	95
	1 hr.	100	0	40	....	6	9	62.5	56	99	95	91	0	....	....	81	90
	4 hr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	24 hr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
No. 4	0.5 hr.	....	....	....	....	50	54	87	58	....	....	....	....	....	....	....	....
	1 hr.	....	....	....	....	2.5	50	62.5	36	....	....	....	....	....	....	....	....
	4 hr.	....	....	....	....	....	....	....	0	....	....	....	....	....	....	....	....
	24 hr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
No. 5	0.5 hr.	100	37	70	0	62	65	90	80	100	100	100	5	0	0	35	16
	1 hr.	100	0	0	....	51	56	65	47	100	72	77	0	....	....	0	0
	4 hr.	100	....	0	....	0	0	0	31	70	0	0	....	....	....	0	0
	24 hr.	100	....	....	....	....	....	....	6	42	....	....	....	....	....	....	....

VACUUM TEST.

Laboratories.	Oil 1A	Oil 2A	Oil 3A	Oil 4A	Oil 1T	Oil 2T	Oil 3T	Oil 4T	Oil 1V	Oil 2V	Oil 3V	Oil 4V	Oil 1C	Oil 2C	Oil 3C	Oil 4C
No. 1	Bad	Bad	Fair	Good	Good	Fair	Fair	Bad	Bad	Bad	Bad	Fair	Good Sep. in 5 min.	Good Sep. in 15min.	Good	Fair
No. 2	Fair	Bad	Bad	Good Sep. in 1 min.	....	....	....	....	....	....	....	....	Good Sep. in 2 min.	Good Sep. in 5 min.	Bad	Good
No. 3	Bad	Fair	Fair	Good	Bad	Fair	Fair	Bad	Bad	Bad	Bad	Good	Good	Good	Good	Fair
No. 5	Fair	Bad	Bad	Good	Fair	Fair	Bad	Bad	Bad	Bad	Bad	Good	Good	Good	Good	Good
No. 8	....	....	....	....	....	....	....	....	Very Poor	Poor	Poor	Excellent	....	....	....	....
No. 10	Fair	Fair	Bad	Good	Fair	Fair	Fair	Fair	Fair	Fair	Bad	Good	Good	Good	Good	Good

VACUUM.

Favorable.—

An oil is either good or no good, and this test makes this differentiation.

If steamed less than 45 minutes, complete hydrolysis of possible sulfonates does not take place, therefore 45 minutes' steaming is used.

Results compare favorably with known conditions in practice.

Not as sensitive to viscosity differences as other tests.

(Comments on last paragraph: The vacuum test is not very sensitive and that is why this statement may seem true, but is not.)

Unfavorable.—

Has not the definiteness of the Conradson.

Fine for plant control in experienced hands, but requires experience in interpreting results.

Results subject to personal interpretation and cannot be expressed in numerical units.

Relative indefiniteness of results.

No differentiation between good oils.

Four sets of four samples each were sent out by sub-committee members to fourteen members of Committee D-2. The recipients of these samples were furnished with explicit directions for making and reporting the Conradson, Herschel, Navy, R.E. and Vacuum tests, these directions having been furnished by the authors of the tests.

The results reported are compiled in Table I which shows that four out of the fourteen recipients did not respond at all, and that others did not make all the tests, either on account of lack of equipment (which is entirely excusable) or of interest.

In spite of most definite instructions for operating and reporting, some of the operators introduced innovations of their own, which has made it impossible to present a comparative tabulation of all the results reported. Innovations in operating undoubtedly account for a number of non-agreements in the results that are susceptible to comparative tabulation.

No attempt is made to present comments on, or an analysis of the results given herewith.

The sub-committee submits with this report a revision of the R.E. Test, with the recommendation that it be printed as an appendix and that it be given a thorough trial with the view of adopting it as a tentative standard.

Respectfully submitted on behalf of the sub-committee,

W. E. PERDEW,
Chairman.

APPENDIX.

SUGGESTED METHOD OF TEST FOR MODIFIED RESISTANCE TO EMULSIFICATION NUMBER OF LUBRICATING OILS.

1. *Scope.*—This method shall be used on all oils when an emulsion, demulsibility or emulsification test is required. This method is commonly used for turbine oils and may be used for other lubricating oils.

2. *Description.*—The Modified Resistance to Emulsification Number (A.S.T.M. R.E.) is the number of minutes required for an oil to separate when emulsified and separated under definitely prescribed conditions.

APPARATUS.

3. *Steam Generator.*—The steam generator shall be made of either metal or glass of at least one liter capacity capable of withstanding heat necessary for continued use in production of steam. It shall be fitted with three outlets with suitable connections for rubber tubing. In case of a metal generator, a large opening for filling and suitable water gage shall be considered a necessary part of the apparatus.

4. *Baths.*—Baths shall be of either metal or glass with a capacity of 3 to 3.5 liters and a depth of 8½ to 9 in. A good quality battery jar or beaker is entirely satisfactory. A glass bath shall be used for emulsification and a metal or glass bath may be used for the separation.

5. *Source of Heat.*—Heat for the steam generator shall be supplied by a suitable gas burner or electric hot plate. The separating bath may be heated by any convenient means, including an auxiliary steam line as shown in Fig. 1.

6. *Oil Container.*—The oil container shall be a 25 by 200-mm. test tube graduated from 0 to 50 cc. in cubic centimeters, each even 5-cc. graduation line to encircle the tube.

7. *Steam Pipe.*—Steam pipe or steam delivery tube, shall consist of a piece of glass tubing exactly 2.5 mm. in inside diameter and 12 in. long. The steam pipe shall be cut off diagonally at an angle of 30 deg. with the axis of the tube at the discharge orifice and shall be bent at a right angle 10 in. from the discharge orifice.

8. *Accessories.*—Accessories shall consist of:

(*a*) Suitable wooden or metal frames or holders for holding oil containers in a vertical position in the baths;

(*b*) Thermometers for separating and emulsifying baths (floating type thermometers of suitable range);

(*c*) Thermometers for oil container tube (engraved-stem type, suitable range, graduated in 1° F., 5 to 7 mm. in diameter.)

(*d*) Corks, rubber tubing and screw pinch cocks.

PROCEDURE.

9. *Preparation.*—The apparatus shall be assembled as shown in Fig. 1. The steam generator shall be filled half full of water and heat applied. Baths shall be filled with 3 liters, ±60 cc. of water. The temperature in the separating bath shall be raised to and maintained at 200 to 203° F.

> NOTE.—Care must be taken if glass battery jars are used, as direct heating by flame or electric hot point may cause breakage. Use of steam in this connection insures against breakage.

Temperature of emulsifying bath shall be brought to 67° F. at the start of the test, and is not controlled thereafter. Twenty cubic centimeters of the oil to be tested shall be measured in the oil container at room temperature and the latter placed in the holder of the emulsifying bath. The steam pipe, or delivery tube, shall be connected to the steam generator with suitable rubber tubing, and screw pinch-cocks placed as shown in Fig. 1.

Care shall be taken to see that the apparatus, particularly the oil container, oil container thermometer and the steam delivery tube, are *chemically clean* before using. Care shall also be taken to prevent any foreign materials from entering the steam generator as any contamination of the steam renders the test valueless.

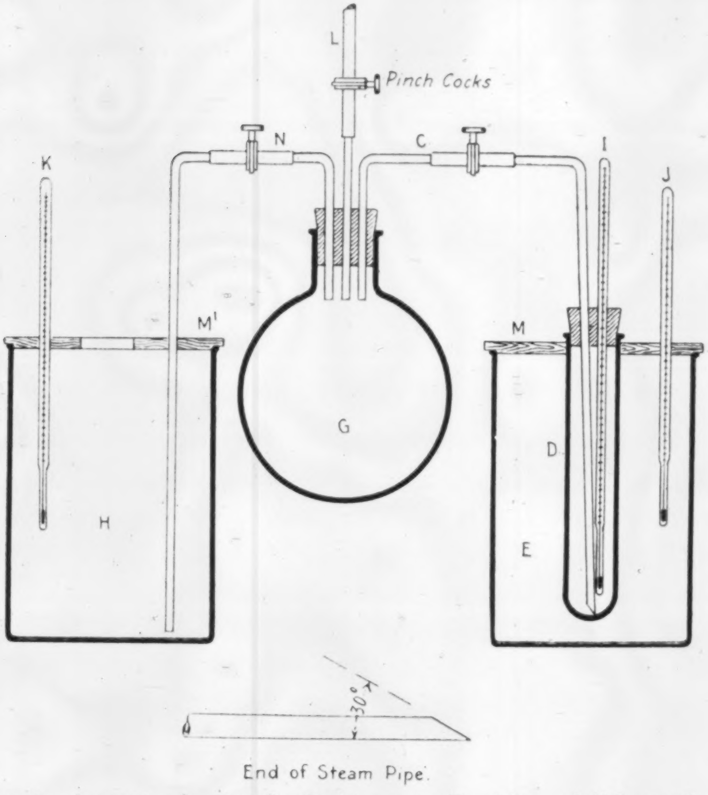

FIG. 1.—Apparatus for Test for Resistance to Emulsion. Self-Generating Steam Supply.

10. *Emulsification.*—The steam delivery tube line shall be steamed out until condensation disappears. A cork having two openings with the thermometer in one shall be placed in the mouth of the oil container. The thermometer shall be adjusted so that the bottom of the bulb is ¾ to 1 in. from the bottom of the oil container. The steam delivery tube shall be inserted through the second opening in cork (NOTE.—This fitting shall be loose) so that the end of the steam delivery tube shall touch the center of the bottom of the oil container. Steam shall be admitted at a rate

that will maintain the temperature of the oil, as shown on the thermometer in the oil container, between 190 and 195° F. (NOTE.—The usual time necessary for the temperature of the oil to come to this point is 45 to 75 seconds, depending on its character.) This control shall be effected by manipulation of the pinch-cocks on the steam delivery line and steam exhaust line from the steam generator. Steam supply shall be sufficient at all times so as to cause a generous discharge from the exhaust line. Steaming shall be continued until the volume of condensed steam and oil in the oil container tube is 40 cc. ± 3 cc. The time required for this operation shall be 4 to 6.5 minutes, depending on the quality of the oil, altitude, etc. If condensed water amounts to 20 cc. in less than 4 minutes, it shall be taken as an indication of wet steam or incomplete steaming out of the line and the test shall be re-run.

> NOTE.—The apparent volume in the tube near the end of the steaming operation is approximately 12 to 15 cc. greater than the actual volume due to displacement caused by steam, thermometer and steam delivery tube.

11. *Separation.*—The steam delivery tube shall be withdrawn as soon as the required volume is obtained. The oil container and holder shall be transferred immediately to the separating bath which shall be maintained at 200 to 203° F. It is extremely important that the temperature of the separating bath be maintained within the given limits. A stop watch shall be started at the instant of withdrawal of the steam delivery tube. The cork containing the thermometer shall be removed after the oil container and contents have been placed in the separating bath. The contents of the oil container shall be examined every 30 seconds, and the volume of the separated oil layer shall be recorded. This examination shall be made by withdrawing the oil container and its contents from the separating bath, and reading the volumes. (NOTE.—This operation shall not require over five seconds.) No differentiation shall be made between clear and turbid oil.

This reading operation shall be continued until 20 cc. of oil has separated. In cases where the 20-cc. oil layer does not separate in 20 minutes, the test shall be discontinued at this point.

In cases where the interface between more-or-less clear oil and the emulsion is not a clear, straight horizontal line, the position of such a line is carefully estimated to the nearest 0.5 cc.

If, at the end of 20 minutes, there is not a well-defined horizontal interface, then, and then only, the contents of the oil container may be stirred for two seconds with a clean glass rod to obtain a better line of demarcation.

12. *Interpretation.*—In interpreting results, the assumption shall be made that the rate of emulsion separation is directly proportional to the Resistance to Emulsification of the tested oil. In order to establish a basis for comparison, a definite value of one shall be assigned to an oil which, under conditions of the test, separates completely from emulsion in one minute. This is equivalent to an emulsion separation rate of 0.33 cc. per second or 20 cc. per minute.

> NOTE.—The expansion of the oil at the higher temperature is disregarded, so when the separation of the oil is complete, as regards the interface between the oil and emulsion layers, the volume of separated oil will always be more than 20 cc. This in no way interferes with the reproducibility of results; and the time shall be recorded when 20 cc.—and not necessarily all—of the oil have separated, when this occurs in less than 20 minutes.

13.—*A.S.T.M. R.E. Number.*—Results shall be reported, in minutes and half minutes, of the time necessary for complete (20 cc.) oil separation. The time in minutes and half minutes shall be reported as the R.E. Number, A.S.T.M. Method. In cases where the required volume shall not have separated in 20 minutes, the oil shall be reported as having an R.E. Number, A.S.T.M. Method, of 20 plus. If duplicate determinations vary by more than one minute, a third test shall be made and the average of the three tests reported.

NOTE.—Oils which emulsify separate into three layers without exception: top, clear or turbid oil; middle, lacey or creamy emulsion; bottom, clear or milky water. The A.S.T.M. R.E. Number is derived from the top layer.

14. *Reproducibility.*—With care and proper attention to details, duplicate determinations of the R.E. Number, A.S.T.M. Method, should not differ by more than 0.5.

REPORT OF SUB-COMMITTEE XII ON FLASH.

The sub-committee recommends that the Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 - 21 T),[1] submitted as tentative last year, be advanced to standard, with the following revision:

Section 3 (*f*).—After the second sentence, add a sentence to read as follows:

> "The first application of the test flame shall be made at a temperature at least 30° F. below the actual flash point."

Respectfully submitted on behalf of the sub-committee,

E. W. Dean,
Chairman.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 655 (1921).

REPORT OF SUB-COMMITTEE XVI ON CLOUD AND POUR TEST.

The sub-committee has been engaged in a study of the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 21 T).[1] A number of suggestions and criticisms have been made. These formed the basis for a series of tests in the laboratories of two of the members of the sub-committee and are included in Table I of this report.

The report of these tests was submitted to the various members of the sub-committee with a questionnaire requesting the opinion of each member on the suitability of the Tentative Method of Test for Cloud and Pour Points for the various petroleum products. A majority of the sub-committee reported that the test was satisfactory and recommended that certain minor changes be made in the test.

Accordingly, Sub-Committee XVI recommends that the tentative method of test be revised as follows:

Section 10.—Change to read as follows:

"*Procedure for Cloud Point.*—The oil to be tested shall be brought to a temperature at least 25° F. above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the oil is perfectly clear, but such filtration shall be made at a temperature at least 25° F. above the approximate cloud point.

"The clear oil shall be poured into the test jar, *a*, to a height of not less than 1 nor more than 1¼ in. The test jar may be marked to indicate the proper level.

"The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb resting on the bottom of the jar.

"The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar with the ring gasket, *f*, 1 in. above the bottom shall be inserted into the jacket. The disk, jacket and inside of jacket shall be clean and dry.

"The temperature of the cooling bath, *g*, shall be adjusted so that it is below the cloud point of the oil by not less than 15 nor more than 30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

"At each test thermometer reading which is a multiple of 2° F. the test jar shall be removed from the jacket, quickly but without disturbing the oil, inspected for cloud, and replaced in the jacket. This complete operation shall require not more than three seconds.

"When such inspection first reveals a distinct cloudiness or haze in the oil at the bottom of the test jar, the reading of the test thermometer, corrected for error if necessary, shall be recorded as the cloud point."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 674 (1921).

TABLE I.—COMPARISON TESTS OF VARIOUS POUR TESTS ON SPECIAL SAMPLES OF OIL.

LABORATORY NO. 1.

Oil.	Modification of Method.[1]	Pour Point, deg. Fahr.	Temperature of Bath, deg. Fahr.
No. 1—J21750 S. Ref. Cyl.	Stood 5 hr	65	38
	No heating, No standing	65	38
	Heated to 180° F., Stood 16 hr	45	20
	Heated to 180° F., Stood 7 days	45	20
No. 2—J21751 Black Oil	Stood 5 hr	30	6
	No heating, No standing	30	0
	Heated to 180° F., Stood 16 hr	−15	−108
	Heated to 180° F., Stood 42 hr	− 5	−108
	Heated to 180° F., Stood 5 days	30	0
No. 3—J21752 Filt. Cyl.	Stood 5 hr	75	48
	No heating, No standing	75	45
	Heated to 100° F	80	56
	Heated to 180° F., Stood 42 hr	95	65
	Heated to 180° F., Stood 48 hr	95	65
	(Heated to 102° F. before testing)	..	...
	Heated to 180° F., Stood 5 days	90	66
	Heated to 180° F., Stood 7 days	90	60
	Heated to 180° F., Stood 8 days	90	60

LABORATORY NO. 2.

Oil	Modification of Method.[1]	Pour Point, deg. Fahr.							
		1st Day.	3d Day.	5th Day.	8th Day.	10th Day.	13th Day.	17th Day.	26th Day.
No. 1 J21750 S. Ref. Cyl.	Stood 5 hr	75	70	70	70	65	65	65	..
	No heating	70	70	70	70	65	65	65	..
	Heated to 120° F	80	75	75	80	80	80	80	..
	Heated to 140° F	..	85	85	80	85	85	85	..
	Heated to 160–175° F.	..	..	40	40	40	40	40	..
No. 2 J21751 Black Oil	Stood 5 hr	35	35	35	35	35	35	35	35
	No heating	below 0	below 0	below 0	below 0	below 0	below 0	below 0	30
	Heated to 120° F	below 0	below 0	below 0	below 0	below 0	below 0	below 0	..
	Heated to 140° F	below 0	below 0	below 0	below 0	below 0	below 0	below 0	below 0
	Heated to 160–175° F.	..	..	below 0	below 0	below 0	below 0	below 0	below 0
No. 3 J21752 Filt. Cyl.	Stood 5 hr	85	80	80	80	75	75	75	..
	No heating	70	75	75	70	70	70	70	..
	Heated to 120° F	85	85	90	90	90	90	90	..
	Heated to 140° F	..	90	95	90	95	95	95	..
	Heated to 160–175° F.	..	..	95	95	95	95	95	..

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[1] All tests were carried out in accordance with the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 –21 T) of the American Society for Testing Materials, *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 674 (1921). The samples were stored at room temperature (65 to 78° F.) and were tested at a laboratory temperature of 70 to 76° F. In all cases the material could be poured from the cans without previous heating. Check determinations were made in all cases. Wherever heating is specified in the Modification of Method, the material was heated to the temperature indicated and allowed to cool slowly, placing it in the bath when the sample had attained a temperature of 90° F.

Section 11.—Change to read as follows:

"*Procedure for Pour Point.*—The oil to be tested shall be brought to a temperature of 90° F., or to a temperature 15° F. higher than its pour point if this pour point is above 75° F. The oil shall then be poured into the test jar, *a*, to a height of not less than 2 nor more than 2¼ in.[1] The jar may be marked to indicate the proper level.

"The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the oil.

"The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar, with the ring gasket, *f*, 1 in. above the bottom, shall be inserted into the jacket. The disk, gasket and inside of jacket shall be clean and dry.

"After the oil has cooled enough to allow the formation of paraffin wax crystals, great care shall be taken not to disturb the mass of the oil nor to permit the thermometer to shift in the oil. Any disturbance of the spongy network of wax crystals will lead to low and fictitious results.

"The temperature of the cooling bath, *g*, shall be adjusted so that it is below the pour point of the oil by not less than 15 nor more than 30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

"At each test thermometer reading which is a multiple of 5° F., the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether the oil around the thermometer remains liquid. As long as the oil around the thermometer flows when the jar is tilted slightly, the test jar shall be replaced in the jacket. The complete operation of removal and replacement shall require not more than three seconds. As soon as the oil around the thermometer does not flow when the jar is tilted slightly, the test jar shall be held in a horizontal position for exactly five seconds and observed carefully. If the oil around the thermometer shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure shall be repeated at the next temperature reading 5° F. lower. In determining the pour point of oils it shall be noted that the first movement of the oil in certain cases is not around the thermometer but from the sides of the test jar. In such cases, this movement shall be considered in making the test. As soon as a temperature is reached at which the oil around the thermometer shows no movement when the test jar is held in a horizontal position for exactly five seconds, the test shall be stopped.

"The lowest reading of the test thermometer, corrected for error if necessary, at which the oil around the thermometer shows any movement when the test jar is held in a horizontal position for exactly five seconds shall be recorded as the pour point. It shall be noted that the pour point is the temperature 5° F. above the solid point or temperature at which the test is discontinued."

The sub-committee recommends that the tentative methods, as revised, be continued as tentative.

Respectfully submitted on behalf of the sub-committee,

T. G. DELBRIDGE, *Chairman.*

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[1] Test jar and contents shall be immediately placed in the previously assembled apparatus.

REPORT OF SUB-COMMITTEE XVII ON GASOLINE.

The sub-committee has been engaged in the study of various properties of gasoline, stressing particularly the tests for corrosion and gumming. Five samples of gasoline, representing various types of material, were examined. The samples are listed in the Appendix.

Detailed results of the common and special tests, with references and discussion of the most important, are given in the Appendix. No recommendations for a satisfactory gumming test can be offered at the present time, as results indicate that considerable work will be necessary to determine the controlling factors. It should be noted that the distillation results, using the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene and Similar Petroleum Products (D 86 – 21 T) are generally concordant.

The sub-committee has prepared a method for corrosion, similar to the Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Petroleum Products (D 89 – 21 T) and submits it with the recommendation that it be presented to the Society as a Tentative Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline.[1]

The sub-committee cooperated with Sub-Committee XI of Committee D-1 in the preparation of a specification for paint thinners other than turpentine.

Respectfully submitted on behalf of the sub-committee.

T. G. Delbridge,
Chairman.

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[1] See p. 780.—Ed.

APPENDIX.

Materials.—The samples tested represent the following different types of gasoline:

No. 1. Current market product in eastern U. S.;
No. 2. Uncracked Mid-Continent gasoline;
No. 3. Cracked Mid-Continent gasoline;
No. 4. Cracked California motor spirits;
No. 5. Gumming gasoline encountered in commercial use.

Tests. Gravity.—Reported in degrees, A. P. I. Scale and Bureau of Standards Baumé Scale, and Specific Gravity. Variations in the scale values call attention to the urgent need for the adoption of a uniform formula for all scale values. This matter has been taken up by the Division of Research of the American Petroleum Institute and is under consideration in the Petroleum Industry at the present time.

Distillation.—Made according to the Tentative Method of Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (D 86 - 21 T).[1] It will be noted that results are generally concordant, the principal exception being one of the results on Sample No. 3, which can be explained by the late arrival of the sample and subsequent loss of the low boiling point fractions.

Sulfur.—Determined by the method for total sulfur, using the bomb, as given in the Report of Sub-Committee VII of Committee D-2 for 1921.[2]

Iodine Number.—Determined by Hanus and The Atlantic Refining Co. (Johansen) methods.

Doctor Test.—Determined by method as given in *Bulletin No. 5.*[3]

Gum.—Determined by the copper dish, porcelain dish, porcelain dish with copper and beaker tests. The copper dish test is described in *Bulletin No. 5.*[3] The other tests are similar to this, the container being variable. Results are expressed in milligrams per 100 cc. of material used.

Corrosion.—Determined by the copper dish test described in *Bulletin No. 5*[3] and the copper strip test similar to the Tentative Method of Test for Detection of Sulfur and Corrosive Sulfur Compounds in Petroleum Products (D 89 - 21 T)[4] using three hours at 150° F., in place of over night standing as given in Method of Test D 89 - 21 T.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 631 (1921).

[2] *Ibid.*, p. 365.

[3] *Bulletin No. 5*, Report of Committee on Standardization of Petroleum Specifications.

[4] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 643 (1921).

TABLE I.—RESULTS OF TESTS ON GASOLINE.
(Motor Gasoline, Eastern Market)

Tests.	Standard Oil Co. (Ind.)	Standard Oil Co. (N. J.)	Bureau of Mines.	Atlantic Refining Co.	United Gas Imp. Co.	Bureau of Standards.	Texas Oil Co.	General Motors Corp.
Gravity	61.2	61.2	60.5	61.3	...	60.9	61.2	...
Sp. Gr. 60/60° F	...	...	0.735	0.7343	0.7367	0.733	0.734	...
Refractive Index	...	...	...	...	1.4082	...	...	...
Distillation, deg. Fahr.:								
Initial	118	118	120	124	...	...	120	...
10 per cent	174	174	180	185	...	...	176	...
20 "	197	199	199	208	...	...	200	...
30 "	216	219	217	224	...	...	217	...
40 "	233	234	234	236	...	...	234	...
50 "	248	248	248	250	...	...	250	...
60 "	264	262	264	260	...	...	265	...
70 "	280	280	284	275	...	...	282	...
80 "	302	300	302	308	...	...	304	...
90 "	334	331	340	340	...	...	331	...
95 "	...	356	...	376	...	...	355	...
Dry "	401	403	405	413	...	...	409	...
Recovery, per cent	98	99	97.2	97	...	...	99.0	...
Residue, "	1.5	...	1.0	2	...	...	1.0	...
Loss, "	0.5	...	1.8	1	...	...	...	...
A. B. P.	248	249	253	251	...	...	251	...
Sulfur, per cent	...	...	...	0.086	...	...	...	...
Abs. by H_2SO_4	4.0	...	3.0	...	5.1	6.0	...	6.0
Nitrated	...	...	...	...	(0.5)	...	...	...
Iodine Number:								
Hanus	10.3	...	...	(1 g.)	...	...	...	...
Atl. Ref. Co. add.	...	...	...	4.82	...	...	...	...
" subst.	...	...	...	3.70	...	...	...	...
" total	...	...	...	12.22	...	...	...	...
$KMnO_4$ test	...	...	...	...	1458	...	...	...
Doctor	...	...	...	...	...	Neg.	O. K.	...
" +S	...	...	...	...	...	...	O. K.	...
Reaction	...	...	...	...	...	Neutral	Neutral	...
Odor	...	...	...	...	...	Good	...	...
Color	...	...	...	...	...	V.L. Straw	0.7[a]	...
Sunlight:								
Sediment	...	...	...	...	...	...	Med. brown	...
Color	...	...	...	...	...	...	4.6[a]	...
Gum:								
Copper dish	5.9	3.1	4.0	3.1	6.0	4.1	2.4	5.3
Porcelain dish	3.4	1.6	...	0.9	3.9	4.5	2.8	3.6
" +Cu	...	3.2	...	1.2	...	...	2.4	...
Beaker	...	...	1.8	...	...	...	...	...
Corrosion:								
Dish	Lt. Br.	...	Dark	Purple	Poor	Slight	V. Slight	...
Strip	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.

[a] 18-in. cell, Lovibond.

TABLE I.—RESULTS OF TESTS ON GASOLINE (*Continued*).

(Uncracked Mid-Continent Gasoline)

Tests.	Standard Oil Co. (Ind.)	Standard Oil Co. (N. J.)	Bureau of Mines.	Atlantic Refining Co.	United Gas Imp. Co.	Bureau of Standards.	Texas Oil Co.	General Motors Corp.
Gravity	57.9	57.8	57.2	56.8	...	57.5	57.8	...
Sp. Gr. 60/60° F	...	...	0.748	0.7518	0.7435	0.747	0.7475	...
Refractive Index	...	...	...	...	1.4130	...	...	...
Distillation, deg. Fahr.:								
Initial	130	124	127	130	...	...	124	..
10 per cent	179	180	183	185	...	...	179	...
20 "	201	205	205	207	...	...	202	...
30 "	220	221	223	225	...	...	220	...
40 "	239	241	241	242	...	...	238	...
50 "	257	261	259	260	...	...	258	...
60 "	279	279	279	277	...	...	280	...
70 "	302	300	306	308	...	...	304	...
80 "	330	324	331	332	...	...	331	...
90 "	363	360	367	366	...	...	366	...
95 "	...	383	...	390	...	...	394	...
Dry "	420	417	421	426	...	...	416	...
Recovery, per cent	98	98.5	97.5	97	...	...	98	...
Residue, "	1.5	...	1.1	1.5	...	...	1.1	...
Loss, "	0.5	..	1.4	1.5	...	...	0.9	...
A. B. P	262	262	268	263	...	...	262	...
Sulfur, per cent	...	...	...	0.034	...	....	...	...
Abs. by H_2SO_4	2.5	...	2.0	...	4.2	5.0	...	4.0
Nitrated	...	...	...	...	0	...	...	...
Iodine Number:								
Hanus	7.7	...	...	(1 gr.)	...	...	...	...
Atl. Ref. Co. add.	...	...	...	3.29	...	...	...	...
" subst.	...	...	...	3.12	...	...	...	...
" total	...	...	...	9.53	...	...	...	...
$KMnO_4$ test	...	...	...	...	300	...	...	...
Doctor	...	...	...	...	...	Neg.	O. K.	...
" +S	...	...	...	...	...	...	O. K.	...
Reaction	...	...	...	...	...	Neutral	Neutral	...
Odor	...	...	...	...	...	Good	...	...
Color	...	...	...	...	...	W. W.	0.6[a]	...
Sunlight:								
Sediment	...	...	...	...	...	...	None	...
Color	...	...	...	...	...	...	2[a]	...
Gum:								
Copper dish	1.5	3.5	2	1.7	1.0	...	2.5	3.7
Porcelain dish	1.85	1.2	...	0.4	0.9	1.4	1.3	1.5
" +Cu	...	1.8	...	...	...	...	1.1	...
Beaker	...	...	3.5	...	...	...	...	...
Corrosion:								
Dish	Lt. Amber	...	Peacock	O. K.	O. K.	...	O. K.	...
Strip	O. K.	O. K.	O. K.	O. K.	O. K.	...	O. K.	..

[a] 18-in. cell, Lovibond.

TABLE I.—RESULTS OF TESTS ON GASOLINE (*Continued*).

(Cracked Mid-Continent Gasoline)

Tests.	Standard Oil Co. (Ind.)	Standard Oil Co. (N. J.)	Bureau of Mines.	Atlantic Refining Co.	United Gas Imp. Co.	Bureau of Standards.	Texas Oil Co.	General Motors Corp.	Cosden and Co.
Gravity	57.4	57.2	56.7	56.0	...	57.4	56.8	...	...
Sp. Gr. 60/60° F	...	...	0.750	0.7550	0.7515	0.747	0.7515	...	...
Refractive Index	...	...	...	...	1.4178	...	...	...	...
Distillation, deg. Fahr.:									
Initial	127	126	129	150	...	...	127	...	130
10 per cent	180	185	185	206	...	...	189	...	175
20 "	209	214	210	227	...	...	215	...	202
30 "	235	239	235	248	...	...	240	...	226
40 "	259	259	261	268	...	...	262	...	246
50 "	280	282	279	288	...	...	283	...	270
60 "	302	300	306	312	...	...	305	...	290
70 "	324	318	327	334	...	...	327	...	318
80 "	343	343	349	356	...	...	349	...	344
90 "	379	374	378	382	...	...	379	...	376
95 "	...	397	...	412	...	...	406	...	400
Dry "	432	432	430	436	...	...	432	...	431
Recovery, per cent	98	98.5	97.5	97	...	...	98.5	...	...
Residue, "	1.5	...	1.0	2	...	...	1.2	...	...
Loss, "	0.5	...	1.5	1	...	...	0.3	...	...
A. B. P.	277	280	280	287	...	...	281	...	...
Sulfur, per cent	...	...	...	0.049	...	...	...	...	...
Abs. by H_2SO_4	11.0	...	11.0	...	9.5	11.0	...	11.0	...
Nitrated	...	...	...	...	0.9	...	...	...	...
Iodine Number:									
Hanus	73.7	...	...	(0.2 gr.)	...	...	...	...	...
Atl. Ref. Co. add.	...	...	...	28.76	...	...	...	...	...
" subst.	...	...	...	24.03	...	...	...	...	...
" total	...	...	...	76.82	...	...	...	...	...
$KMnO_4$ test	...	...	...	...	11680	...	...	...	...
Doctor	...	...	...	...	...	Neg.	O. K.	...	...
" +S	...	...	...	...	...	...	O. K.	...	...
Reaction	...	...	...	...	...	Neutral	Neutral	...	...
Odor	...	...	...	...	...	Good	...	...	...
Color	...	...	...	...	...	V.L.Straw	1.8[a]	...	...
Sunlight:									
Sediment	...	...	...	...	...	...	None	...	...
Color	...	...	...	...	...	...	S. G.	...	...
Gum:									
Copper dish	5.4	6.2	6.0	8.4	12.4	13.5	4.7	5.5	..
Porcelain dish	1.4	1.4	...	2.4	1.8	9.0	0.8	1.4	...
" +Cu	...	4.9	...	3.3	...	...	1.9	...	...
Beaker	...	...	3.2	...	...	...	...	...	...
Corrosion:									
Dish	Varnish	O. K.	Tarnish	Gummy	Good	Bl. Gum	Br. Gum	...	...
Strip	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	...

[a] 18-in. cell, Lovibond.

TABLE I.—RESULTS OF TESTS ON GASOLINE (*Continued*).

(Cracked California Motor Spirit)

Tests.	Standard Oil Co. (Ind.)	Standard Oil Co. (N. J.)	Bureau of Mines.	Atlantic Refining Co.	United Gas Imp. Co.	Bureau of Standards.	Texas Oil Co.	General Motors Corp.
Gravity	46.5	46.3	45.0	46.0	...	45.0	45.7	...
Sp. Gr. 60/60° F	...	...	0.8000	0.7974	0.7995	0.796	0.7985	...
Refractive Index	...	...	...	...	1.4462	...	...	...
Distillation, deg. Fahr.:								
Initial	110	108	104	114	...	...	112	...
10 per cent	168	167	167	178	...	...	176	...
20 "	204	207	203	214	...	...	212	...
30 "	236	237	237	245	...	...	245	...
40 "	265	266	268	269	...	...	271	...
50 "	291	293	291	298	...	...	294	...
60 "	312	311	315	315	...	...	314	...
70 "	330	333	333	332	...	...	333	...
80 "	347	349	349	352	...	...	350	...
90 "	367	369	369	371	...	...	368	...
95 "	...	381	...	386	...	...	381	...
Dry "	394	396	396	408	...	...	394	...
Recovery, per cent	98	98	97	97	...	...	98	...
Residue, "	1	...	1.2	2	...	...	1	...
Loss, "	1	...	1.8	1	...	...	1	...
A. B. P	275	276	276	279	...	...	279	...
Sulfur, per cent	...	...	...	0.109	...	...	...	...
Abs. by H_2SO_4	23.0	...	25.5	...	36.0	24.0	...	...
Nitrated	...	...	...	...	5	...	...	...
Iodine Number:								
Hanus	155	...	...	(0.15 gr.)	...	...	...	...
Atl. Ref. Co. add.	...	...	...	186.49	...	...	...	...
" subst.	...	...	...	39.40	...	...	...	...
" total	...	...	...	265.29	...	...	...	...
$KMnO_4$ test	...	...	...	...	431	...	...	...
Doctor	...	...	Neg.	...	Neg.	Neg.	Bad	...
" +S	...	...	...	...	...	...	Bad	...
Reaction	...	...	O. K.	...	...	Neutral	Neutral	...
Odor	...	...	Very Poor	...	...	Poor	...	...
Color	...	...	Yellowish	+0.8 Say.	...	L. Straw	9^a	...
Sunlight:								
Sediment	...	...	...	...	...	...	Br. Prec.	...
Color	...	...	...	...	...	...	3.3^a	...
Gum:								
Copper dish	375	250	593.2	336.7	795.4	424.5	293.6	...
Porcelain dish	27.2	57.5	46.9	28	23.8	20	41.2	...
" +Cu	...	150	...	89.8	...	...	95.2	...
Beaker	...	...	...	...	...	...	...	...
Corrosion:								
Dish	Bl. Gum	...	Varnish	Varnish	Good	Bl. Gum	Dk. Gum	...
Strip	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	

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[a] 18-in. cell, Lovibond.

TABLE I.—RESULTS OF TESTS ON GASOLINE (*Continued*).

(Gumming Gasoline)

Tests.	Standard Oil Co. (Ind.)	Standard Oil Co. (N. J.)	Bureau of Mines.	Atlantic Refining Co.	United Gas Imp. Co.	Bureau of Standards.	Texas Oil Co.	General Motors Corp.
Gravity	67.7	67.7	66.6	67.3	...	67.2	67.4	...
Sp. Gr. 60/60° F	...	...	0.712	0.7122	0.7126	0.7098	0.7115	...
Refractive Index	...	...	...	...	1.3966	...	...	...
Distillation, deg. Fahr.:								
Initial	116	...	115	122	...	...	116	...
10 per cent	151	...	154	158	...	...	158	...
20 "	162	...	163	167	...	...	167	...
30 "	170	...	172	177	...	...	175	...
40 "	180	...	181	186	...	...	184	...
50 "	189	...	190	195	...	...	192	...
60 "	198	...	201	205	...	...	202	...
70 "	209	...	212	214	...	...	213	...
80 "	221	...	226	230	...	...	225	...
90 "	242	...	250	253	...	...	246	...
95 "	...	...	...	284	...	...	268	...
Dry "	286	...	297	302	...	...	289	...
Recovery, percent	98	...	97	97	...	...	98	...
Residue, "	1	...	0.8	2	...	...	1	...
Loss, "	1	...	2.2	1	...	...	1	...
A. B. P	193	...	197	198	...	...	...	...
Sulfur, per cent	...	...	...	0.015	...	...	...	...
Abs. by H_2SO_4	10.0	...	11.0	...	6.4	8.0	...	...
Nitrated	...	...	...	...	0.6	...	...	...
Iodine Number:								
Hanus	46.5	...	...	(0.5 gr.)	...	...	...	...
Atl. Ref. Co. add.	...	...	...	34.96	...	...	...	...
" subst.	...	...	...	6.08	...	...	...	...
" total.	...	...	...	47.12	...	...	...	...
$KMnO_4$ test	...	...	...	...	95	...	...	...
Doctor	...	...	Neg.	...	Neg.	Neg.	Bad	...
" +S	...	...	...	...	...	...	Bad	...
Reaction	...	...	Acid	...	...	Neutral	Neutral	...
Odor	...	...	Poor	Cracked	...	Poor	...	...
Color	...	...	W. W.	W. W.	...	W. W.	S. G.	...
Sunlight:								
Sediment	...	...	...	...	...	...	...	...
Color	...	...	...	...	...	...	...	...
Gum:								
Copper dish	25.4	20.5	29.8	19.0	27.4	29.5	23.5	...
Porcelain dish	17.5	7.0	...	...	4.8	37.0	21.8	...
" +Cu	...	16.4	...	...	...	...	25.4	...
Beaker	...	...	...	...	...	...	...	...
Corrosion:								
Dish	Gum	...	Gum	Gum	Good	Gum	Gum	...
Strip	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	...

REPORT OF COMMITTEE D-4

ON

ROAD AND PAVING MATERIALS.

Since its last report was presented to the Society, Committee D-4 has made considerable progress in the preparation of specifications and methods of test, although it has as yet been unable to develop absolutely satisfactory descriptions of certain tests which are referred to in some of its tentative specifications. Sectional committees are at present working on these tests and it is hoped that next year the committee will be in a position to recommend for adoption as standard many of the tentative specifications which it requests be allowed to remain as tentative for the present.

No. 1. *Standard Method of Test for Softening Point of Bituminous Materials other than Tar Products (Ring-and-Ball Method) D 36 - 21.*[1]—Since the adoption of this method an error has been discovered in the description of the apparatus. Committee D-4 therefore recommends that the following correction be approved by the annual meeting without requiring a change in the date of last revision.

Section 2 (a). Change the second sentence from its present form: namely,

> "This ring shall be attached in a convenient manner to a No. 15 B. & S. gage brass wire (diameter 1.79 mm. =0.0703 in.)."

to read as follows:

> "This ring shall be attached in a convenient manner to a No. 13 B. & S. gage brass wire (diameter 1.83 mm. =0.072 in.)."

Attention is called to the fact that if this correction is approved, the gage of wire shown in Fig. 1 should be changed from No. 15 to No. 13.

No. 2. *Tentative Specifications for Block for Granite Block Pavements (D 59 - 19 T).*[2]—The committee has found no reason to make any important change in this tentative standard and therefore recommends it to the Society for adoption as standard, with the following minor corrections:

Section 2.—Change the requirements from their present form: namely,

"FOR HEAVY TRAFFIC.

French coefficient of wear	not less than 11
Toughness	" " " 9

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 690 (1920).

FOR MODERATELY HEAVY TRAFFIC.

French coefficient of wear	not less than 8
Toughness	" " " 7"

to read as follows:

"FOR HEAVY TRAFFIC.

Percentage of wear	not more than 3.6
(French coefficient of wear	not less than 11)
Toughness	not less than 9

FOR MODERATELY HEAVY TRAFFIC.

Percentage of wear	not more than 5
(French coefficient of wear	not less than 8
Toughness	not less than 7"

Section 6 (*b*).—Change the last sentence from its present form: namely,

"All blocks which fail to conform to the requirements of Sections 1, 5 and 6 shall be rejected."

to read as follows:

"All blocks which fail to conform to the requirements of Sections 1, 4 and 5 shall be rejected."

No. 3. *Tentative Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including some Material Survey Methods* (*D 75 - 20 T*).[1]—No criticisms of these methods have been received and as the committee has found no reason to change them they are recommended to the Society for adoption as standard.

No. 4. *New Tentative Test Recommended as a Substitute for the Standard Method of Test for Quantity of Clay and Silt in Sand for Highway Construction* (*D 74 - 21*).[2]—As a result of conference with Committee C-9, Committee D-4 recommends that the Proposed Tentative Method of Decantation Test for Sand and Other Fine Aggregates appended to the report of Committee C-9[3] be published as tentative as a substitute for the Standard Method of Test D 74 - 21. It is understood that Committee C-9 is in accord with this recommendation. The committee accordingly recommends the withdrawal of the Standard Method of Test D 74 - 21.

No. 5. *New Tentative Test Recommended as a Substitute for Tentative Specifications for Workability of Concrete for Concrete Pavements* (*D 62 - 20 T*).[4]—The committee, after considerable study of the slump test, believes that the presentation of the Tentative Specifications D 62 - 20 T was somewhat premature and recommends that this specification be withdrawn and that the Proposed Tentative Method of Test for Consistency of Portland-Cement Concrete for Pavements or for Pavement Base appended hereto[1] be published as tentative in its place.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, p. 789 (1920).

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 802.—ED.

[4] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, p. 692 (1920).

No. 6. *Tentative Specifications for Coal-Tar Pitch for Block Filler (D 112 – 21 T).*[2]—The committee considers that the material covered by the Tentative Specifications D 112 – 21 T is not suitable for use as a filler for all types of block and recommends that the title of these specifications be changed by inserting the word "Stone" before the word "Block" so that it shall read as follows:

"Tentative Specifications for Coal-Tar Pitch for Stone Block Filler."

No. 7. *Tentative Specifications for Calcium Chloride for Dust Prevention (D 98 – 21 T).*[3]—The committee has thought it advisable to broaden in some respects the Tentative Specifications D 98 – 21 T and at certain places to insert more detailed requirements. It therefore recommends that these tentative specifications be amended as follows:

1. *Section 2.*—Change to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

"[The] calcium chloride shall be in the form of loose dry lumps or flakes [free from dust] and fine enough to feed readily through the common forms of spreaders used in road work, *and when tested by means of laboratory screens and sieves shall meet the following requirements:*

Passing $^3/_8$-in. screen	*100 per cent*
Retained on $^1/_4$-in. screen	*not more than 20 per cent*
Passing 20-mesh sieve	*not more than 10 per cent*"

2. *Section 3.*—Change to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

"Ten grams of the material dissolved in 100 cc. of boiling water shall show less than 1.0 per cent insoluble residue. Not more than [0.5] *1.0* cc. of normal acid shall be required to neutralize the alkalinity of the filtrate, *using methyl orange.* [The percentage of calcium chloride shall be not less than 70 per cent of the material tested.] *The chemical composition shall conform to the following requirements:*

$CaCl_2$ (anhydrous), per cent	*not less than 73.*
$MgCl_2$, per cent	*not more than 0.5*
NaCl, per cent	*not more than 2.0*
Other impurities, per cent	*not more than 1.0*

The percentage of $CaCl_2$ shall be calculated from the percentage of calcium in the filtrate above referred to, after making a deduction for the SO_4, which shall be assumed to be in combination as $CaSO_4$."

3. *Section 4.*—Change from its present form: namely,

"The calcium chloride shall be delivered in tight steel drums about 21 in. in diameter and 32 to 34 in. in height. The name of the manufacturer, the lot number, the percentage of calcium chloride guaranteed by the manufacturer and the net weight of contents, shall be plainly marked on each drum."

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[1] See p. 805.—ED.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 702 (1921).

[3] *Ibid.*, p. 679.

to read as follows:

"The calcium chloride shall be delivered in air-tight moisture-proof bags or sacks containing approximately 100 lb. each, or in air-tight steel drums weighing not more than 350 lb. each. The name of the manufacturer, the lot number, the approximate net weight, and the percentages of calcium chloride guaranteed by the manufacturer shall be plainly marked on each container."

4. *Section 5.*—Change from its present form: namely,

"Every facility for inspection shall be provided the purchaser at the plant. The manufacturer shall take and retain a sealed sample of each car lot of calcium chloride and shall deliver same to the purchaser, provided the purchaser does not elect to have his own representative present at the plant when the car is sampled."

to read as follows:

"Every facility shall be provided the purchaser should he elect to have his own representative sample the material at the plant. If the purchaser decides to sample the material after delivery in the field it is understood that a 3-per-cent variation in content of $CaCl_2$ from the chemical composition stated in Section 3 shall be permissible."

5. *Section 6.*—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"Calcium chloride shall be rejected if it fails to pass any of *the requirements of* these specifications and if it [cakes or becomes sticky in the drums] *has become caked or sticky in the containers before opening.*"

No. 8. *Tentative Specifications for Asphalt Cement (D 99 - 21 T) (D 100 - 21 T) (D 101 - 21 T) (D 102 - 21 T) (D 103 - 21 T).*[1]—The committee recommends that the five tentative specifications for asphalt cement be amended as follows:

1. *Titles.*—Change to read as follows by the addition of the italicized words:

"Tentative Specifications for Asphalt Cement, 40 to 50 Penetration, *for Use in Sheet Asphalt and Asphaltic Concrete Pavements.*

"Tentative Specifications for Asphalt Cement, 50 to 60 Penetration, *for Use in Sheet Asphalt and Asphaltic Concrete Pavements.*

"Tentative Specifications for Asphalt Cement, 60 to 70 Penetration, *for Use in Sheet Asphalt, Asphaltic Concrete, and Asphalt Macadam Pavements.*

"Tentative Specifications for Asphalt Cement, 70 to 90 Penetration, *for Use in Asphalt Macadam Pavements.*

"Tentative Specifications for Asphalt Cement, 90 to 120 Penetration, *for Use in Asphalt Macadam Pavements.*"

2. *Section 1.*—In each of the five specifications omit Section 1 on "Scope," renumbering the following sections accordingly.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, pp. 681-685 (1921).

3. *Section 2 (e).*—In specifications D 101, D 102 and D 103, change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

"(*e*) Ductility at 25° C. (77° F.)..............not less than [40] *30* cm."

4. *Section 2 (f).*—In each of the five specifications omit the requirement for "Bitumen Soluble in Carbon Disulfide" and substitute therefor the following:

"(*f*) Proportion of bitumen soluble in carbon
tetrachloride..........................not less than 99 per cent"

5. *Section 3 (e).*—In each of the five specifications omit the reference to the method of determining bitumen soluble in carbon disulfide and substitute therefor the following:

"(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Method contained in *Bulletin No. 314*, U. S. Department of Agriculture."

In connection with recommendation 5, the committee wishes to state that it has nearly completed a tentative method of determining the proportion of bitumen soluble in carbon tetrachloride but until the few remaining details are worked out it prefers to refer to the method described in *Bulletin No. 314* of the U. S. Department of Agriculture.

No. 9. *Tentative Method of Test for Ductility of Bituminous Materials (D 113 - 21 T).*[1]—The committee recommends that this method be amended as follows:

1. *Section 5.*—Change the last sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

"It shall [then] be left to cool [in the air at a temperature not lower than 15.5° C. (60° F.),] *to room temperature and then placed in water maintained at 25° C. (77° F.)* for 30 minutes, after which the excess of bitumen shall be cut off by means of a hot putty knife or spatula so that the mold shall be just level full."

2. *Section 7.*—Change the second sentence to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

"While the test is being made, the water in the tank of the ductility machine shall cover the sample by at least [5] *2.5* cm. and shall be kept continuously at a temperature within 0.5° C. of 25° C. (77° F.)."

No. 10. *Proposed Tentative Specifications and Methods of Tests.*—Committee D-4 recommends that the following proposed tentative specifications and methods of test appended hereto[1] be published as tentative:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 704 (1921).

(*a*) Specifications for Block for Recut Granite Block Pavements;
(*b*) Specifications for Block for Durax Granite Pavements;
(*c*) Specifications for Asphalt Cement, 120 to 150 Penetration, for use in Asphalt Macadam Pavements;
(*d*) Specifications for Asphalt Cement, 10 to 15 Penetration, for the Manufacture of Asphalt Block;
(*e*) Specifications for Asphalt Cement, 15 to 25 Penetration, for the Manufacture of Asphalt Block;
(*f*) Method of Mechanical Analysis of Subgrade Soils;
(*g*) Method of Float Test for Bituminous Road Materials.
(*h*) Methods of Sampling Bituminous Materials.

TABLE I.

Items.	Affirmative.	Negative.	Not Voting.
I. TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD.			
Tentative Specifications for Block for Granite Block Pavements (D 59 - 19 T)	30	0	24
Tentative Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including some Material Survey Methods (D 75 - 20 T)	31	0	23
II. REVISION OF EXISTING STANDARD RECOMMENDED FOR ADOPTION.			
Standard Method of Test for Softening Point of Bituminous Materials other than Tar Products (Ring-and-Ball Method) (D 36 - 21)	31	1	22
III. PROPOSED TENTATIVE STANDARDS RECOMMENDED AS SUBSTITUTE FOR EXISTING STANDARDS OR TENTATIVE STANDARDS.			
Proposed Tentative Method of Decantation Test for Sand and other Fine Aggregates as substitute for Standard Method of Test D 74 - 21	31	2	21
Proposed Tentative Method of Test for Consistency of Portland Cement Concrete for Pavements or for Pavement Base as substitute for Tentative Specifications D 62 - 20 T	26	1	27
IV. PROPOSED REVISIONS OF EXISTING TENTATIVE STANDARDS.			
Tentative Specifications for Coal-Tar Pitch for Block Filler (D 112 - 21 T)	25	3	26
Tentative Specifications for Calcium Chloride for Dust Prevention (D 98 - 21 T)	29	2	23
Tentative Specifications for Asphalt Cement, 40 to 50 Penetration (D 99 - 21 T)	25	5	24
Tentative Specifications for Asphalt Cement, 50 to 60 Penetration (D 100 - 21 T)	25	5	24
Tentative Specifications for Asphalt Cement, 60 to 70 Penetration (D 101 - 21 T)	25	5	24
Tentative Specifications for Asphalt Cement, 70 to 90 Penetration (D 102 - 21 T)	25	5	24
Tentative Specifications for Asphalt Cement, 90 to 120 Penetration (D 103 - 21 T)	25	5	24
Tentative Method of Test for Ductility of Bituminous Materials (D 113 - 21 T)	31	1	22
V. PROPOSED NEW TENTATIVE STANDARDS.			
Proposed Tentative Specifications for Block for Recut Granite Block Pavements	28	0	26
Proposed Tentative Specifications for Block for Durax Granite Pavements	28	0	26
Proposed Tentative Specifications for Asphalt Cement, 120 to 150 Penetration, for Bituminous Macadam Pavements	23	5	26
Proposed Tentative Specifications for Asphalt Cement, 10 to 15 Penetration, for the Manufacture of Asphalt Block	25	3	26
Proposed Tentative Specifications for Asphalt Cement, 15 to 25 Penetration, for the Manufacture of Asphalt Block	24	4	26
Proposed Tentative Method of Mechanical Analysis of Subgrade Soils	29	1	24
Proposed Tentative Method of Float Test for Bituminous Road Materials	32	0	22
Proposed Tentative Methods of Sampling Bituminous Materials	31	0	23

The results of a letter ballot of the committee upon the recommendations which have been made relative to the adoption of tentative standards and the submission of new standards are as given in Table I.

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[1] See pp. 786–789, 792–793, 799, 803, and 809–814.—ED.

This report has been submitted to letter ballot of the committee, which consists of 54 members, of whom 30 have voted affirmatively, none negatively, and 24 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. H. BLANCHARD,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE.

The proposed revision of the Standard Method of Test for Softening Point of Bituminous Materials other than Tar Products (Ring-and-Ball Method) referred to in this report was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, as a correction of the standard method.

The Tentative Specifications for Block for Granite Block Pavements amended as indicated in this report and the Tentative Methods of Sampling Stone, Slag, Gravel, Stone and Stone Block for Use as Highway Materials, including Some Material Survey Methods were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1922.

The proposed revision of the Standard Method of Test for Quantity of Clay and Silt in Sand for Highway Construction was accepted for publication as a new tentative method entitled "Tentative Method of Decantation Test for Sand and Other Fine Aggregates," and appears on page 802.

The proposed Tentative Method of Test for Consistency of Portland-Cement Concrete for Pavements or for Pavement Base was accepted for publication as tentative and appears on page 805, as a revision of the Tentative Specifications for Workability of Concrete for Concrete Pavements.

The proposed revisions of the seven tentative specifications listed in items Nos. 6 to 8 of this report were accepted. The specifications as thus revised appear on pages 800, 790 and 794–798.

The proposed revisions of the Tentative Method of Test for Ductility of Bituminous Materials referred to in Item No. 9 of this report were accepted. The method as thus revised appears on page 807.

The eight proposed new tentative standards referred to in Item No. 10 of this report were accepted for publication as tentative and appear on pages 786–789, 792–793, 799, 803, and 809–814.

REPORT OF COMMITTEE D-5

ON

COAL.

Committee D-5 held two meetings during the past year, one at Asbury Park, N. J., June 20, 1921, and one at Philadelphia, Pa., March 1, 1922.

Experimental work has been conducted on a comparison of the micropyrometer method with the standard gas-furnace method for the determination of the fusibility of coal ash. Extensive work has been done on investigating specification forms for the purchase of coal for use in steam power plants, formulating definitions and terms relating to coal, and preparing specifications for gas and by-product coal.

Micropyrometer Method for Coal Ash Fusibility.—Sub-Committee I on Methods of Testing, A. C. Fieldner, Chairman (this sub-committee is part of a joint committee with the American Chemical Society, W. A. Noyes, Chairman), conducted an extensive comparison of the micropyrometer method and the standard gas-furnace method for the determination of the fusibility of coal ash. A large number of samples of coal ash, covering a wide range of fusibility, were selected for making the tests. It was found that the two methods checked fairly well on most coal ash fusing below 2600° F. by the gas-furnace method, but that very refractory ash, fusing above 2600° F. by the gas-furnace method, gave much lower results by the micropyrometer method; consequently the two methods can not be used as alternative methods. Further work will be done in correlating fusibility of coal ash, as determined by the two methods, with actual furnace operation. It is recommended that the Tentative Method of Test for Fusibility of Coal Ash (D 22 - 19 T), which employs the gas-furnace method, be continued as tentative until such time as experience will show which method agrees best with furnace practice.

Tentative Revisions of Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 - 21).—The designation of porcelain ware by number has led to some confusion, as all manufacturers do not use the same number in designating similar sizes. It is recommended that sizes only be specified and that the following revisions in the Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 – 21)[1] be published as tentative:

On page 764 of the 1921 Book of A.S.T.M. Standards, line 5, omit "No. 2," substituting in place thereof the word "a"; on page 766, line 4, omit "No. 2"; on page 769, beginning with the third line under Apparatus, change the following paragraph from its present form: namely,

> "*Porcelain, Silica, or Platinum Crucibles or Capsules.*—For igniting coal with the Eschka mixture.
>
> "No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.
>
> "No. 1 porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coal, owing to the deeper form, than with the shallow capsules described above.
>
> "No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the $BaSO_4$."

to read as follows:

> "*Porcelain, Silica, or Platinum Crucibles or Capsules.*—Porcelain capsules, $\frac{7}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, or porcelain crucibles of 30 cc. capacity, high or low form, or platinum crucibles of similar size are to be used for igniting coal with the Eschka mixture.
>
> "Porcelain, platinum, alundum, or silica crucibles of 10 to 15 cc. capacity, are to be used for igniting the $BaSO_4$."

On page 770, under Method, change the second sentence in the first paragraph, on Preparation of Sample and Mixture, from its present form: namely,

> "Transfer to a No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 crucible or a platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

to read as follows:

> "Transfer to a porcelain capsule, $\frac{7}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, or a porcelain crucible of 30 cc. capacity, high or low form, or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

Revisions of Tentative Method of Test for Fusibility of Coal Ash (D 22 – 19 T).—It is recommended that the following revisions be made in the Tentative Method of Test for Fusibility of Coal Ash (D 22 – 19 T):[2]

On page 799 of Part I of the Proceedings for 1920, line 9, omit "No. E," change "$4\frac{1}{2}$ in." to read "$3\frac{1}{2}$ in.," and "3 in." to read "$2\frac{7}{8}$ in.," and in line 12, change "$4\frac{5}{8}$ in." to read "$4\frac{3}{4}$ in."

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mat., Vol. XX, Part I, p. 796 (1920).

Nomenclature and Definitions.—Sub-Committee II, H. C. Porter, Chairman, has formulated definitions of terms as applied to coal. The committee feels that a standardization of the meaning of such terms is needed by and will be of benefit to many branches of science, industry, and commerce. It is recommended that the definitions of terms appended hereto[1] be accepted by the Society for publication as tentative. Additional definitions are now being formulated and will be presented next year.

Specifications for Gas and By-Product Coal.—Sub-Committee III, A. H. White, Chairman, in conjunction with a committee of the American Gas Association, is engaged in the preparation of specifications for gas and by-product coal. These specifications are to define the essential qualifications of coals suitable for the manufacture of gas or metallurgical coke. The sub-committee has the specifications largely completed and they will be presented to the Society next year.

Forms of Specifications and Standard Sizes.—Sub-Committee IV, Hubb Bell, Chairman, in conjunction with fuel committees of the National Association of Purchasing Agents and the National Electric Light Association, made an extensive study of specifications for the purchase of coal for use in steam power plants. They reported that it is impossible to formulate standard specifications for steam coal owing to the peculiar conditions obtaining at each plant. The selection of coal for a given plant is necessarily governed by its own particular furnace installation and by the economically available coals of the district in which it is located.

In the course of its work, Sub-Committee IV collected from various sources a large number of forms of specifications and contracts for purchasing coal used by Federal, State, and Municipal Governments, Public Utilities, and other corporations. From this data a general form of specification contract for purchasing coal was prepared by the sub-committee and reported to the main committee. The general committee decided that this "form of specification or contract" was a business rather than a technical matter and therefore was outside the province of the standards of the Society. The chairman of the sub-committee was therefore requested to read a separate paper before the Society on the subject of "Forms of Specifications,"[2] to include the general contract form and other business matters, for the benefit of those interested in the buying and selling of coal for steam power plants.

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[1] See p. 825.—Ed.

[2] This paper appears in Part II of the *Proceedings*, p. 567. For a general discussion on coal purchase specifications, see Part II of the *Proceedings*, p. 572.—Ed.

In conjunction with committees of the American Mining Congress and the American Society of Mechanical Engineers, Sub-Committee IV will consider the standardization of anthracite sizes during the coming year.

This report has been submitted to letter ballot of the committee, which consists of 32 members, of whom 23 have voted affirmatively, 1 negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

W. A. SELVIG,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Standard Methods of Laboratory Sampling and Analysis of Coal were accepted for publication as tentative and appear on page 992.

The proposed revisions of the Tentative Method of Test for Fusibility of Coal Ash were accepted. The method of test as thus revised appears on page 815.

The proposed Tentative Definitions of Terms Relating to Coal referred to in this report were accepted for publication as tentative and appear on page 825.

REPORT OF COMMITTEE D-6

ON

COKE.

Committee D-6 held two meetings in the past year, one at Asbury Park, N. J., June 20 and 21, 1921, and the other at Pittsburgh, Pa., March 15, 1922.

Extensive experimental work has been conducted on the reproducibility and significance of tests for determining the physical properties of coke.

Shatter Test.—The shatter test which has been in common use for some years was standardized and a series of comparative tests was made by several laboratories using both the shatter testing machine and a simplified form of this test in which the coke was placed in a bag and dropped from a height of 6 ft. upon a steel plate or concrete floor from three to five times. Each of the laboratories participating in this investigation was able to so conduct the bag test that similar results were obtained to that of the shatter test machine as shown in Table I.

However, it was apparent that certain slight modifications in the procedure produced different results so that one operator recommends three drops, another four, and another five in order to obtain the same results as with the machine shatter test. After careful consideration of the results obtained, the committee decided to eliminate the bag shatter test from further consideration. It is recommended that the Tentative Method of Shatter Test for Coke (using machine) appended to this report[1] be accepted for publication as tentative.

Tumbler Test.—Experimental work in the use of the tumbler barrel for determining the "hardness" or "friability" of coke did not furnish sufficiently definite information on the interpretation or practical value of the results to justify recommending this test as tentative at the present time. Further investigations will be carried on by the committee during the coming year.

Combustibility Tests.—The relative combustibility of coke in air and the rate of reaction with carbon dioxide are thought to be important factors in the suitability of coke for metallurgical purposes. The committee has experimental work in progress on this phase of the subject and hopes to report progress next year.

Porosity of Coke.—Experimental work is being conducted on methods for determining the specific gravity and cell space of coke. It is hoped to present tentative methods for their determination next year.

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[1] See p. 822.—Ed.

Tentative Revisions of Standard Methods of Laboratory Sampling and Analysis of Coke (D 37 - 21).—The designation of porcelain ware by number has led to some confusion as all manufacturers do not use the same number to designate similar sizes. It is therefore recommended that sizes only be specified and that the following revisions in the Standard Methods for Laboratory Sampling and Analysis of Coke (D 37 - 21)[1] be published as tentative:

TABLE I.—COMPARISON OF MACHINE AND BAG SHATTER TESTS BY DIFFERENT OPERATORS ON VARIOUS COKES.

Operator.	Coke.	Machine.			Bag.			Difference between Bag and Machine Tests.
		Number of Drops.	Number of Tests.	Retained on 2-in. Screen, average, per cent.	Number of Drops.	Number of Tests.	Retained on 2-in. Screen, average, per cent.	
A..............	1	4	10	58.9	3	10	67.3	+8.4
A..............	2	4	10	62.9	3	10	72.5	+9.6
B..............	3	4	20	52.5	3	20	53.1	+0.6
B..............	4	4	1	43.9	4	1	35.3	−8.6
C..............	5	4	4	68.6	3	4	73.7	+5.1
D..............	6	4	1	76.0	3	1	84.0	+8.0
D..............	6	..	..	....	4	1	82.0	+6.0
D..............	6	..	..	....	6	1	74.0	−2.0
D..............	7	4	1	74.0	3	1	80.0	+6.0
D..............	7	..	..	....	4	1	76.0	+2.0
D..............	7	..	..	....	5	1	72.0	−2.0
D..............	8	4	1	80.0	3	1	86.0	+6.0
D..............	8	..	..	....	4	1	80.0	0.0
D..............	9	4	1	76.0	3	1	82.0	+6.0
D..............	9	..	..	....	4	1	77.0	+1.0
E..............	10	4	5	71.8	4	10	68.9	−2.9
E..............	11	4	13	76.3	4	17	77.3	+1.0
E..............	12	4	10	69.6	4	8	67.1	−2.5

On page 790 of the 1921 Book of A.S.T.M. Standards, line 1, omit "No. 2"; on page 791, line 4, omit "No. 2"; on page 794, beginning with the third line under Apparatus, change the following paragraph from its present form: namely,

"*Porcelain, Silica, or Platinum Crucibles or Capsules.*—For igniting coke with the Eschka mixture.

"No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.

"No. 1 porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coke owing to the deeper form, than with the shallow capsules described above.

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[1] 1921 Book of A.S.T.M. Standards.

"No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the $BaSO_4$."

to read as follows:

"*Porcelain, Silica, or Platinum Crucibles or Capsules.*—Porcelain capsules, ⅞ in. deep and 1¾ in. in diameter, or porcelain crucibles of 30 cc. capacity, high or low form, or platinum crucibles of similar size are to be used for igniting coke with the Eschka mixture.

"Porcelain, platinum, alundum, or silica crucibles of 10 to 15 cc. capacity, are to be used for igniting the $BaSO_4$."

On page 795, under Method, change the first paragraph on Preparation of Sample and Mixture from its present form: namely,

"*Preparation of Sample and Mixture.*—Thoroughly mix on glazed paper, 1 g. of 60-mesh coke and 3 g. of Eschka mixture. Transfer to a No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 porcelain crucible or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

to read as follows:

"*Preparation of Sample and Mixture.*—Thoroughly mix on glazed paper, 1 g. of 60-mesh coke and 3 g. of Eschka mixture. Transfer to a porcelain capsule, ⅞ in. deep and 1¾ in. in diameter, or a porcelain crucible of 30 cc. capacity high or low form, or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

Tentative Definitions of Terms Relating to Coke (*D 121 - 21 T*).—It is recommended that the Tentative Definitions of Terms Relating to Coke be allowed to stand as tentative for another year to permit their review and coordination with definitions of terms relating to coal, by Committee E-8.

This report has been submitted to letter ballot of the committee, which consists of 17 members, of whom 12 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

RICHARD MOLDENKE,
Chairman.

A. C. FIELDNER,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Standard Methods of Laboratory Sampling and Analysis of Coke referred to in this report were accepted for publication as tentative and appear on page 993.

The proposed Tentative Method of Shatter Test for Coke referred to in this report was accepted for publication as tentative and appears on page 822.

REPORT OF COMMITTEE D-7

ON

TIMBER.

Committee D-7 held one meeting during the year. The principal activities for the year have been centered in the sub-committees, and considerable progress is being made.

One of the important phases of the work of Committee D-7 is that which is vested in Sub-Committee IX on Methods of Testing. This sub-committee during the past year has devoted its efforts to the preparation of specifications governing methods of testing small clear specimens of timber. This problem was undertaken first because of its importance at the present time. It is the intention to give consideration to methods of testing structural timbers at a later date.

As pointed out in the last report, the work on methods of testing has proceeded with the thought in mind of developing standards which will give data comparable to that now available for over 150 species of wood, embracing over a half million tests, and at the same time, embody such modifications as experience has shown desirable. On this basis, Sub-Committee IX has prepared Tentative Methods of Testing Small Clear Specimens of Timber,[1] which are recommended for publication as tentative. The methods were submitted to letter ballot of the committee, which consists of 37 members, of whom 23 have voted affirmatively, none negatively, and 14 have refrained from voting.

Sub-Committee I on Classification and Designation of Southern Yellow Pines is now studying the specifications for Southern yellow pine, and is taking under consideration the advisability of modifying the present rules for this species as appearing in the Standard Specifications for Yellow-Pine Bridge and Trestle Timber (D 10 – 15).

The Sub-Committee on Nomenclature and Definitions has under way the revision of the Definitions of certain terms, particularly the definitions of shakes and checks. A questionnaire was sent to different members of Committee D-7 to obtain the viewpoint of the whole committee. After sub-committee action, the definitions will be presented to the main committee for consideration.

Committee D-7 is cooperating with Committee E-1 on Methods of Testing in its effort to unify the distillation test methods of the various standing committees, and is represented on the Sub-Committee on Volatility (formerly Sub-Committee on Unification of Distillation Tests) which was formed for this purpose. Extensive experimentation is being carried on to obtain data which will permit an intelligent study of the methods of distillation before the sub-committee.

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[1] See p. 827.—Ed.

This report has been submitted to letter ballot of the committee, which consists of 37 members, of whom 23 have voted affirmatively, none negatively, and 14 have refrained from voting.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE.

The proposed Tentative Methods of Testing Small Clear Specimens of Timber referred to in this report were accepted for publication as tentative and appear on page 827.

REPORT OF COMMITTEE D-8
ON
WATERPROOFING MATERIALS.

For a number of years past Committee D-8 has made no formal report to the Society. During this period, however, it has undergone reorganization and since the last annual meeting has made considerable progress in the formulation of tentative methods of test and sampling and in the revision of the tentative specifications for which it was originally responsible.

Many new members have been secured and a number of new sub-committees have been created. While some of these sub-committees have as yet been unable to produce results which warrant the committee in making definite recommendations to the Society, it is felt that before the next annual meeting much additional material will be available upon which to base the committee's report. The present organization of the committee includes the following sub-committees:

On Nomenclature and Definitions.
On Service Tests.
On Bituminous Grouts and Mastics.
On Membrane Waterproofing Materials.
On Waterproofing Signal Wire Conduits and Electrical Installations.

Proposed Revision of Tentative Specifications.

1. *Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing* (*D 40 - 17 T*).[1]—The committee has given very careful consideration to the revision of these tentative specifications and recommends as a substitute the following two specifications appended hereto[2] to be published as tentative:

(*a*) Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing below Ground Level.
(*b*) Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing above Ground Level.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 716 (1920).
[2] See pp. 863–866.—Ed.

2. *Tentative Specifications for Primer for Use with Asphalt for Use in Damp-proofing and Waterproofing (D 41 - 17 T).*[1]—The committee has completely revised these specifications so as to make them more complete and at the same time applicable for use with the two new specifications referred to in the preceding paragraph. It therefore recommends that they be accepted for publication as tentative in their proposed revised form as appended hereto[2] under the title "Tentative Specifications for Primer for Use with Asphalt in Damp-proofing and Waterproofing below and above Ground Level."

3. *Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing (D 42 - 17 T).*[3]—The same policy regarding these specifications has been followed as in the case of the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing. The committee therefore recommends that as a substitute the following two specifications appended hereto[4] be published as tentative:

(*a*) Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing below Ground Level.

(*b*) Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing above Ground Level.

4. *Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing (D 43-17 T).*[5]—In line with the recommendation for revision of the Tentative Specifications for Primer for Use with Asphalt, the committee recommends that these specifications as revised be accepted for publication as tentative as appended hereto[6] under the title "Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch in Damp-proofing and Waterproofing below and above Ground Level."

NEW METHODS SUBMITTED AS TENTATIVE.

5. Committee D-8 recommends that the following proposed tentative methods appended hereto[7] be published as tentative:

(*a*) Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

(*b*) Methods of Testing Bituminous Mastics, Grouts and Like Mixtures.

(*c*) Method of Sampling Bituminous Materials Shipped in Barrels or Drums.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 720 (1920).

[2] See p. 867.—ED.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 721 (1920).

[4] See pp. 869–872.—ED.

[5] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 725 (1920).

[6] See p. 873.—ED.

[7] See pp. 875–891.—ED.

The results of a letter ballot of the committee upon the recommendations which have been made relative to the submission of new standards are as follows:

Items.	Affirmative.	Negative.	Not Voting.
I. PROPOSED TENTATIVE STANDARDS RECOMMENDED AS SUBSTITUTE FOR EXISTING TENTATIVE STANDARDS.			
Proposed Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing below Ground Level	22	1	5
Proposed Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing above Ground Level	23	0	5
(NOTE.—These two specifications to be substituted for Tentative Specifications D 40 - 17 T.)			
Proposed Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing below Ground Level	22	0	6
Proposed Tentative Specifications for Coal-Tar Pitch for Use in Damp-Proofing and Waterproofing above Ground Level	22	0	6
(NOTE.—These two specifications to be substituted for Tentative Specifications D 42 - 17 T.)			
II. PROPOSED REVISIONS OF EXISTING TENTATIVE STANDARDS.			
Tentative Specifications for Primer for Use with Asphalt for Use in Damp-proofing and Waterproofing (D 41 - 17 T)	22	1	5
Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing (D 43 - 17 T)	22	0	6
III. PROPOSED NEW TENTATIVE STANDARDS.			
Proposed Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing	22	0	6
Proposed Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures	22	0	6
Proposed Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums	23	0	5

This report has been submitted to letter ballot of the committee, which consists of 28 members, of whom 22 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. N. FORREST,
Vice-Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE.

The proposed Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing below Ground Level and the proposed Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing above Ground Level were accepted for publication as tentative and appear on pages 863–866, as revisions of the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing. The proposed Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing below Ground Level and the proposed Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing above Ground Level were accepted for publication as tentative and appear on pages 869-872 as revisions of the Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing.

The proposed revisions of the Tentative Specifications for Primer for Use with Asphalt for Use in Damp-proofing and Waterproofing and of the Tentative Specifications for Creosote Oil for Priming Coat with Coal-Tar Pitch for Use in Damp-proofing and Waterproofing were accepted. The tentative specifications as thus revised appear on pages 867 and 873, respectively.

The proposed Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing, the proposed Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures and the proposed Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums were accepted for publication as tentative and appear on pages 875-891.

REPORT OF COMMITTEE D-9
ON
ELECTRICAL INSULATING MATERIALS.

The committee has held two meetings during the year in addition to the one to be held during this annual meeting of the Society. Both of the former meetings were held in New York, one on November 22, 1921, and the other on March 3 and 4, 1922.

The activities of the committee have been along the lines followed in preceding years: namely, the development and standardization of tests and test procedures for electrical insulating materials of various kinds. The work is carried on by six sub-committees dealing with the various general classes of materials as follows:

Varnishes.
Molded materials.
Sheet or laminated insulation.
Liquid insulation.
Porcelain.
Cable splicing and pot-head compounds.

EXISTING STANDARDS.

This committee has four tentative standards before the Society at the present time. The following action on these tentative standards is recommended:

Tentative Methods of Testing Molded Insulating Materials (*D 48 - 21 T*).[1]—These methods of test have been published as tentative for five years during which time no important criticism has been received. Certain minor revisions were made last year but none of these has been criticised. These methods are now generally recognized as the standard in the art and the committee recommends that they be adopted as standard.

Tentative Methods of Testing Insulating Varnishes (*D 115 - 21 T*).[2] —A few criticisms of these methods and suggestions for improvement having been received, the committee recommends that the following revisions be made:

Section 4.—Experience shows that fire point is unimportant in these varnishes if a flash test is made. Accordingly, change Section 4 from its present form: namely,

> "4. *Apparatus.*—(*a*) The flash point shall be measured with a closed-cup tester and the fire point with an open-cup tester.
>
> "(*b*) The type of tester shall be stated in the report."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 711 (1921).

[2] *Ibid.*, p. 722.

to read as follows:

"4. *Procedure for Flash Point.*—The flash point shall be determined in accordance with the Standard Method of Test for Flash Point of Volatile Flammable Liquids (Serial Designation: D 56) of the American Society for Testing Materials."

Section 5.—Omit this section, reading as follows, renumbering the remaining sections accordingly:

"5. The rate of heating shall be about 2 to 3° C. (3.6 to 5.4° F.) per minute for low flash point varnishes and about 5 to 8° C. (9 to 14° F.) per minute for high flash point varnishes. The test flame shall not be applied oftener than once every 3° C. (5.4° F.) for low flash point varnishes; or 5° C. (9° F.) for high flash point varnishes. The first application of the test flame shall be at a temperature not lower than 10° C. (18° F.) below the flash point. The test flame shall be applied at a distance of about 1 cm. (0.394 in.) from the surface of the varnish."

Section 7 (b).—To take care of the variation in the characteristic of time of setting in different varnishes, change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"In the case of baking varnishes, six specimens shall be dipped and allowed to drain [for 30 minutes] at a room temperature of approximately 20° C. (68° F.) [and then] ***until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger will not become obliterated by further flow of the material. They are then to be*** dried in free air in an oven at approximately 100° C. (212° F.). At the end of the first 30 minutes, and again at the end of each 10-minute period thereafter, one specimen shall be taken from the oven and examined."

Section 10 (a).—Change the second sentence from its present form: namely,

"The potential shall be applied at a low value and gradually raised at a rate of approximately 500 volts per second until puncture occurs."

to read as follows:

"The potential shall be applied at a low value and gradually raised at a rate such that puncture will occur in about ten to fifteen seconds."

This change is recommended in order to eliminate the heating effect as much as possible and make the test consistent with the proposed Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials submitted with this report.

Section 14.—Change from its present form: namely,

"For the heat endurance test, a specimen shall be prepared as in Section 9. After first removing not less than 1.27 cm. (0.5 in.) from one edge, 7 strips shall be cut from the same edge, each 1.9 cm. (0.75 in.) wide."

to read as follows:

"For the heat endurance test, specimens shall be prepared as in Section 9. After removing not less than 12.7 mm. (0.5 in.) from one edge of the specimens.

the required number of strips shall be cut from the same edge, each 19 mm (0.75 in.) wide."

Section 15 (a).—Change from its present form: namely,

> "(*a*) Six of the seven specimens prepared for this test shall be placed in a uniformly heated oven in which the temperature is maintained at 100° C. (212° F.) within ± 5° C. (9° F.). A specimen shall be removed at the end of 50, 100, 200, 300, 400 and 500 hours respectively and, together with the initial specimen, shall be tested as follows at a room temperature of approximately 20° C. (68° F.)."

to read as follows:

> "After setting as shown by the test indicated in Section 7 (*b*), the strips referred to in Section 14 shall be placed in a uniformly heated oven in which the temperature is maintained at 100° C. (212° F.) within ± 5° C. (9° F.). A strip shall be removed at the end of 1, 2, 4, 8 and 24 hours respectively and every 24 hours thereafter. These, together with the initial strip, shall be tested as follows at a room temperature of approximately 20° C. (68° F.)".

The committee recommends that the tentative methods of test as revised be continued as tentative.

Two new sections, on solid content and rate of evaporation, respectively, have been tentatively agreed upon but are not yet in final form. They will be submitted at the next annual meeting with perhaps a section on draining.

Tentative Methods of Testing Electrical Porcelain (D 116 - 21 T).[1]—This method of test has been approved by the Committee on Standards of the American Ceramic Society. However, certain minor changes have been suggested but the committee requires further time to study the proposed changes and it is therefore recommended that these methods be continued as tentative for another year.

Tentative Methods of Testing Transformer and Switch Oils (D 117 - 21 T).[1]—No criticisms of this tentative standard have been received, but it is desirable that the methods prescribed be made more comprehensive by the inclusion of a so-called sludging test before recommending that these methods be advanced to standard. The committee is not yet prepared to recommend a procedure for this additional test (this is referred to elsewhere in this report) and therefore desires that these methods be continued as tentative.

PROPOSED NEW TENTATIVE STANDARDS.

The following two new methods have been prepared and are recommended by the committee for publication as tentative:

(*a*) Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21 (1921).

(*b*) Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials.

These proposed tentative methods are appended to this report.[1]

WORK OF SUB-COMMITTEES.

The following is a brief summary of the activities during the year, other than those concerned with the preceding paragraphs, which have engaged or are still engaging the attention of the sub-committees:

(*a*) *Insulating Varnishes.*—As with many other materials, an important need in connection with the testing of insulating varnishes is a method of evaluating the results of a series of different tests on two or more competing materials in a way that will show numerically the relative order of the quality. The committee is studying a method which has been developed by one of its members, John A. Findley. As this problem is one of general interest, a condensation of Mr. Findley's proposal is given in the Appendix to this report.

The committee is giving consideration to the matter of a standard of color, and, in conjunction with the Sub-Committee on Sheet Insulating Materials, to tests for temperature-dielectric strength characteristic, tests for temperature-power factor characteristic and tests for dielectric constant.

(*b*) *Molded Materials.*—An important test for these materials which is not yet included in the Methods of Testing Molded Insulating Materials is an impact test. The sub-committee has given considerable thought to this matter but has delayed making a recommendation until the general subject of standardization of impact tests has been reported upon by Committee E-1. However, the committee desires to take this opportunity to emphasize the urgent need for such action so that it can proceed with the standardization of an impact test procedure.

The sub-committee is preparing methods of testing these materials for high frequency, high voltage applications. It is also considering the preparation of material specifications for certain grades of molded materials.

(*c*) *Sheet Insulation.*—The materials being studied by the Sub-Committee on Sheet Insulation have been classified as follows:

(*a*) Flexible sheet materials;
(*b*) Non-flexible sheet materials;
(*c*) Untreated paper and similar materials;
(*d*) Rods, tubing and special shapes formed from sheet materials (*i. e.*, not molded).

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[1] See pp. 897–917.—ED.

The standardizing of tests and procedures for all of these materials is obviously an extensive undertaking. So far the sub-committee has agreed upon the following as the tests which should be considered in connection with flexible sheet materials:

1. Momentary dielectric strength test;
2. Dielectric endurance test;
3. Surface insulation resistance with low voltage, direct current;
4. Surface insulation resistance with high voltage, alternating current;
5. Dielectric constant;
6. Power factor of charging current;
7. Specific resistance;
8. Heat conductivity;
9. Heat endurance;
10. Moisture absorption;
11. Effect of oil;
12. Acid and alkali proof test;
13. Tensile strength;
14. Tearing strength;
15. Dielectric strength of bias-cut material when under tension.

As the development of the procedures for many of these tests will require considerable time, it is planned to offer each procedure as a tentative standard as it is prepared by the committee and then eventually combine them into one standard. By this method the membership will have available the separate test procedures as they are completed. The present status is as follows:

Item 1 is completed (a tentative method is being submitted with this report); a draft of a procedure for item 2 has been prepared and is being given an experimental trial by members of the committee; procedures for items 5, 6, 7, 8 and 10, respectively, are in course of preparation.

Referring to untreated paper, a draft of a test method has been prepared and is now being studied by the committee. It includes the following tests:

1. Fiber analysis;
2. Acidity;
3. Moisture content;
4. Heat endurance test;
5. Ash content;
6. Castor oil rise test;
7. Mechanical tests.

(*d*) *Liquid Insulations.*—The sub-committee dealing with liquid insulation has been engaged on the problem of finding what test or tests determine the deterioration of transformer oil in service. This matter was referred to in the report of the committee last year at which time the hope was expressed that during the year a satisfactory test would be developed. The so-called sludging test has been considered in the past the best measure of the serviceability of transformer oils, but experimental work by one of the members of the committee has developed inconsistencies between this test and other tests which have been proposed. Apparently these inconsistencies were due to differences in interpretation of, or the limited information in, the published procedures for these various tests. The committee therefore had to first study the various procedures and agree upon the exact details of procedure. This has been done and four different laboratories are now carrying out each of the following tests on the same sample of each of three grades of oil, the exact details of procedure for each of the tests having been agreed upon after much correspondence:

1. Deposit test (formalite test);
2. Iodine or bromine value;
3. Sludging test (after Michie procedure);
4. Tar test (after the so-called German 9 procedure).

Upon completion of this investigation it is expected that a test method can be recommended to cover the serviceability characteristic of oils. When this is done, the committee will also be in position to recommend a material specification for transformer oil.

A paper on this general subject entitled "The Problem of Durability Tests for Transformer Oils" is being presented at this annual meeting of the Society by T. G. Delbridge,[1] a member of this committee.

(*e*) *Cable Splicing Compounds.*—A new sub-committee was appointed during the year to standardize the tests and procedures for this class of insulating materials. The following have been agreed upon as the tests which should be covered in a standard method, and it is expected that tentative methods will be recommended next year.

1. Softening point;
2. Flash and fire tests;
3. Rate of evaporation;
4. Temperature-viscosity characteristic to 100° C.;
5. Penetration;
6. Coefficient of expansion, both in solid and liquid states;

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[1] This paper appears in Part II of the *Proceedings*, p. 532.—ED.

7. Brittleness;
8. Adhesion;
9. Temperature-dielectric strength characteristic from $-25°$ C. to $+100°$ C.

The following is the result of the letter ballot vote of the committee (33 members) on those recommendations in this report which deal with adoption of existing tentative standards, with revisions of existing tentative standards and with proposed new tentative standards:

Items.	Affirmative.	Negative.	Not Voting.
I. TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION.			
Advancing the present Tentative Methods of Testing Molded Insulating Materials (D 48 - 21 T) to standard	20	0	13
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS.			
Revision of the Tentative Methods of Testing Insulating Varnishes (D 115 - 21 T)	18	0	15
III. PROPOSED NEW TENTATIVE STANDARDS.			
Proposed Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials	19	0	14
Proposed Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies	17	0	16

This report has been submitted to letter ballot vote of the committee, which consists of 33 members, of whom 25 have voted affirmatively, none negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. FARMER,
Chairman.

H. S. VASSAR,
Secretary.

EDITORIAL NOTE.

The Tentative Methods of Testing Molded Insulating Materials referred to in this report were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 25, 1922, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1922.

The proposed revisions of the Tentative Methods of Testing Insulating Varnishes referred to in this report were accepted. The tentative methods as thus revised appear on page 892.

The proposed Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials and the proposed Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies were accepted for publication as tentative and appear on pages 897–917.

APPENDIX.

NUMERICAL TABULATION AND COMPARISON OF VARNISH TESTS.

By John A. Findley.

Outside of pure research laboratories, the final objective of any set of insulating varnish tests is practical, not academic. Tests are made to determine what product of a certain class is best adapted to the purpose for which we desire to use it. Final judgment must take into account both intrinsic merit and cost and in cases where little is known of the materials, allow each investigator to use his own experience to weight his decision. The reason why varnish tests and, for that matter, those on other insulating products have given inconclusive results in the past is that they only outline procedure. They should besides, to be of most service, classify and group all varnishes of the same type by preliminary definition and then indicate a method of expressing test results in terms that can be correlated with reference to each other and cost. If they accomplish these points they will also give data which will eventually lead to interpretation of results and the consequent formation of a real picture of the materials and their relative merits. Whether at the outset the basis is absolutely sound or not is immaterial, providing it is flexible enough to allow for ameliorations which future progress will bring and tends to promote such progress and thought where up to now very little has been possible.

Is it possible to combine all these desiderata with our present or future methods of varnish tests so as to allow one to discuss results in a universal language and form an idea of relative merits even from tests of others? The following suggestions, while possibly faulty in some points of reasoning, are at least an attempt in this direction and have in practice allowed the writer and his assistants to transmit information definitely and clearly. They have been presented in more extended form to the judgment of others and considered at least worthy of closer study.

The first necessity in any scheme is of course the expression in exact terms of individual test results. We talk, for instance, of specific gravity of varnish and have a test outlined for its measurement. The result is expressed in figures; yet this figure is of little value to the user for comparative purposes as it stands because it is only the expression of the weight of the mixture of the real product in which he is interested plus a varying percentage of more or less heavy thinner. If however the specific gravity were expressed as an equation in which also appeared the weight and percentage of solvent, a figure may be obtained which is far more exact and in addition allows ready calculation of the volume and specific gravity of the solid content or useful material itself. Such an expression would aid the user and the manufacturer alike. Again, if viscosity is considered, it will be found that we are determining an impractical value of a resultant of two forces. What we really want to know is how viscosity will affect thickness of coat and covering power after setting. The qualities of the admixed solvent are as important in such a determination as those of the solid content of the varnish.

With regard to test on the qualities of the varnish after it is set, we are in a better position as we can even now by agreement set down the results in figures—for instance, "Disruptive Strength" in volts per mil, "Acid or Alkali Resistance" in hours until breakdown, and so on. When this has been done we have an exact set of figures representing our results on a particular material.

There are as yet no unit bases to which to compare specifically each of our results because up to the present they have been expressed in such terms as "fair", "poor", etc., and not in figures. There is however the possibility of determining such either from the average results of tests on a number of representative materials or by the individual investigator considering the best value in any given test as a basis to which the values given by the other products he is considering are to be compared numerically. For instance, if on the test of three varnishes we obtain an acid resistance of 10, 8, and 6 hours, respectively, 10 is considered the base and the other relative values are 8 and 6. If in these same samples, the respective disruptive strengths are 1000, 1400, and 1500 volts per mil, 1500 is the base to which the others are compared.

Suppose for brevity that these two qualities are the only ones of interest in a given case, we must decide which of the three varnishes we are to choose as having the most merit for our work. We can set down beforehand two figures totaling an ideal 100 per cent which represent our idea of the relative importance to the whole of the qualities considered.

A manufacturer of small motors operating in places where acid is present might say that it was three times as important that his varnish possess acid resistance as that it show high dielectric strength. Expressing this thought in per cent would mean that he considered the acid value as forming 75 per cent of the ideal total and the disruptive strength value as 25 per cent.

Putting down in a table the test results originally found, the bases of comparison and the ideal percentage values as we judge them, we get the following:

Qualities Considered.	Actual Test Results.			Basis of Comparison.	Ideal Relative Values.	Translation of Test Results to Relative Values.		
	Sample No. 1.	Sample No. 2.	Sample No. 3.			Sample No. 1.	Sample No. 2.	Sample No. 3.
Dielectric strength......	1000	1400	1500	1500	25	17	23	25
Acid resistance.........	10	8	6	10	75	75	60	45
Totals earned in test after valuation..........................					100	92	83	70

It would seem from the above that Sample No. 1 was nearest to meeting our needs in the ratio of 92 to 83 or 92 to 70. But the purchasing agent states he can buy Sample No. 1 for $1.10 per gallon, Sample No. 2 for $1.05 and Sample No. 3 for $0.95. How are we to correlate our test values with these prices?

It will have been noticed that in the test procedure all tests are based upon equal thicknesses of coat. This means that an equal volume of the solid content or varnish base has been considered and used irrespective of its concentration which may be more or less according to its particular qualities or the type of solvent used in thinning. We must therefore determine the volume of solid content contained per gallon or other unit of varnish. This can readily be done by a distillation test.

Suppose that we find the three samples contain 45, 40 and 47 per cent of base by volume respectively and that on account of their other qualities, to obtain equal specified thicknesses of coat, additions of 10, 4 and 15 per cent of solvent were necessary respectively. Let us resort to another table and combine all these figures so as to obtain the final relative values sought for:

	SAMPLE No. 1.	SAMPLE No. 2.	SAMPLE No. 3.
Totals earned in test table above....................	92	83	70
Percentage of base or solid content..................	45	40	47
Percentage of solvent added to get equal coat.........	10	4	15
Cost of varnish per gallon as supplied................	$1.10	$1.05	$0.95
Cost of solvent as supplied........................	.25	.22	.22
Total cost of thin varnish in state tested............	1.125	1.06	0.983
Gallonage obtained in state tested..................	1.10	1.04	1.15
Cost per gallon in state tested......................	$1.02	$1.02	$0.86
Percentage of base in state tested.................	41	38	41
Actual relative value figure. (This is the figure earned in test multiplied by the percentage of base of the thin product and divided by its cost.)..............	37	31	34

It appears from the above that, having reduced all our results to a numerical and comparative basis and taking into account all observations we have made together with the actual cost, we have obtained a relative value for the three samples. In this case the most expensive has shown the higher relative value. It will be seen however that any variation in any of the figures above will change the final value.

For instance, if Sample No. 3 had earned a test total of say 80 its final value would have worked out as 38, or higher than Sample No. 1. Of course a minimum limit can also be set on the ideal values for any quantity and the samples which show tests below these limits should not be further considered. If in the future the testing of insulating materials should become entirely standardized, this system can still be applied and at that time the value of goods tested in other laboratories can be translated on a percentage basis to one's own ideal and so the relative merits of different articles for one's particular need can be determined without going to the trouble of making further tests upon points for which there already exist test values.

There may be a flaw in the reasoning by which final figures are arrived at but it has not been pointed out up to the present time. No criticism can be made as to the elasticity of the scheme nor as to its adaptability to any and all modifications in test procedure. Results of different investigators can be set down by it and average values finally determined which may take the place of our own. Even the personal factor of the investigator is allowed for, as well as the correlation of any two sets of tests, provided one of the products tested is common to each.

There are many other points not mentioned here on account of lack of space which should prove of importance not only in testing insulating varnishes but also in any series of tests where actual and exact standards do not as yet exist.

REPORT OF COMMITTEE D-10

ON

SHIPPING CONTAINERS.

Since submitting its last report, Committee D-10 has held a meeting at Asbury Park in connection with the last annual meeting of the society and a meeting in Chicago on April 6.

At the Asbury Park meeting there was considerable discussion of the subject of nomenclature and definitions, and it was agreed that there was real need for standard definitions of terms used in connection with shipping containers and their use. The sub-committee responsible for this subject has given considerable thought to it during the year, and although no definite report can be made now it is hoped real progress can be reported at the next annual meeting.

The importance of determining what shipping containers are proper and efficient and of prescribing clear and definite specifications for them has been recently recognized in a very active manner by the American Railway Association. The executive committee of that Association, in connection with their drive to reduce loss and damage, has ordered the Bureau of Explosives to expand its test and specification department to include the investigation of shipping containers for all kinds of commodities and to prepare recommendations in the form of specifications for the properly efficient container; the expansion is referred to as the Freight Container Bureau, but is directly a part of the Bureau of Explosives, with which, as well as with its work, we are all familiar.

The Freight Container Bureau is investigating shipping containers from a purely engineering standpoint, which will, of course, involve special consideration of proper economies and the standardization of types as well as the actual efficiency of construction for transportation purposes. Investigations are being made at plants making the containers and at plants using them; shipments are also to be followed and observed at railway stations and steamship piers to determine actual results in transit. Following the customary practice of the Bureau of Explosives, a thorough effort will be made to work with and through all interested associations so that the work, when completed, will have their indorsement and support. Committee D-10 can doubtless give a great deal of assistance by cooperating with the Freight Container Bureau and enabling them to take advantage of the progress which we have made, and thus avoid duplication of effort.

The action of the American Railway Association clearly showed the wisdom of the American Society for Testing Materials in forming Committee D-10 a number of years ago, and will enable that committee to give, as well as to receive, valuable assistance in the formulation of proper standards for shipping containers. The committee is in close touch with the Freight Container Bureau and close cooperation will be maintained at all times, in order that the best interests of all concerned may be served.

A member of Committee D-10 is an official representative of the American Society for Testing Materials on an advisory committee of experts formed by the Freight Container Bureau in connection with the work outlined.

During the past year, the sub-committee on nailed and lock-cornered containers has worked assiduously to improve the specifications for this type of container. Appended hereto is a revision of the present General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction. This revision involves numerous slight changes from the present version as well as a few more important ones. It is recognized that the schedule for the sizes and spacing of nails should be improved. The committee has given considerable attention to this point but has reached the conclusion that it does not wish to recommend changes at this time.

The most important change offered in the revised specifications is the addition of a rule for the strapping of boxes (see Section 15), and for the permissible reduction in thickness of lumber when strapping is used (see Section 16).

It is to be emphasized that the inclusion of these strapping rules in these specifications does not mean that all boxes moving in transportation must be strapped but that when strapped boxes are required, these regulations should govern. These regulations must be tentative for the present because regulations governing the use of round metal strapping, which the committee is not ready to present, are needed to make them complete. When detailed specifications for unstrapped boxes are prescribed, strapped nailed boxes with thinner sides, tops, and bottoms may be used. This optional provision makes for increased reliability in the serviceability of boxes and tends to practical economies.

There is under way at the Forest Products Laboratory a study of defects in lumber as these affect the strength and serviceability of wooden boxes. This is a fundamental study and when completed will permit the re-drafting of that part of the general specifications which refers to quality of materials.

Further changes in and additions to the General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction will, undoubtedly, be found desirable. Specifications for the use of screws are needed. Regulations defining the use of single-ply and three-ply lumber with reinforcing cleats will soon be necessary; and these are only a few of the additions which present themselves. Because of the need for such revisions and additions, the General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction should continue as tentative for some time to come.

Committee D-10 recommends that the revised tentative specifications appended hereto[1] be approved to replace the present Tentative General Specifications for Wooden Boxes Nailed and Lock-corner Construction (D 68 - 20 T).[2] The result of the letter ballot of the committee on this recommendation is as follows: Affirmative, 22; negative, 1; not voting, 12.

Committee D-10 also recommends that the present Tentative Specifications for Wooden Boxes, Nailed, and Lock-Corner Construction for the Shipment of Canned Foods (D 44 - 20 T) be continued.

This report has been submitted to letter ballot of the committee, which consists of 35 members, of whom 20 have voted affirmatively, none negatively, and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. A. Newlin,
Chairman.

T. R. C. Wilson,
Secretary.

Editorial Note.

The proposed revisions of the Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, were accepted. The tentative specifications as thus revised appear on page 918.

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[1] See p. 918.—Ed.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 730 (1920).

REPORT OF COMMITTEE D-11
ON
RUBBER PRODUCTS.

The committee has held two meetings during the year in addition to the one to be held during the present meeting of the Society. Both were held in New York, one on November 21, 1921, and the other on March 6 and 7, 1922.

RECOMMENDATIONS IN REFERENCE TO EXISTING STANDARDS.

At the present time this committee has before the Society one standard method and ten tentative specifications and the committee makes the following recommendations in regard to them:

(*a*) *Standard Methods of Testing Cotton Rubber-Lined Hose (D 15 - 15).*[1]—Specifications for various kinds of hose were the first standards prepared by the committee and naturally the first methods of testing were designed especially for hose. But, as specifications for other materials were developed, this standard procedure for testing hose was still referred to for such procedures as were applicable to the particular material involved. The committee believes that the time has arrived to replace these standard methods by others which are more general in their scope. It therefore recommends that the Tentative Methods of Testing Rubber Products referred to later in this report be accepted to replace, when adopted, the Standard Methods of Testing Cotton Rubber-Lined Hose (D 15 - 15).[1]

(*b*) *Tentative Specifications for Insulated Wire and Cable: 30-Per-Cent Hevea Rubber (D 27 - 21 T)*,[2]

(*c*) *Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public Fire Department Use (D 26 - 21 T)*,[2]

(*d*) *Tentative Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 - 21 T)*,[2]

(*e*) *Tentative Specifications for Braided Air Hose for Use with Pneumatic Tools (D 60 - 21 T)*,[2]

(*f*) *Tentative Specifications for Steam Hose (D 54 - 21 T)*,[2] and

(*g*) *Tentative Specifications for Rubber Belting for Power Transmission (D 53 - 21 T)*.[2]—The committee recommends that all of these specifications be continued as tentative. Where, however, references are now contained to the Standard Methods of Testing Cotton Rubber-Lined Hose, such reference should be changed to the proposed Tentative Methods of Testing Rubber Products, should these be approved.

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21 (1921).

(*h*) *Tentative Specifications for Cotton Rubber-Lined Fire Hose for Private Fire Department Use* (*D 14 - 21 T*).[1]—These specifications are now limited to $2\frac{1}{2}$-in., single-jacketed hose. The committee recommends that they be expanded to include additional sizes as follows: $1\frac{1}{2}$-in. and 2-in. single and double-jacketed, $2\frac{1}{2}$-in. double and triple-jacketed, and 3-in. and $3\frac{1}{2}$-in. double and triple-jacketed.

The changes which will be necessary in the present specifications to include these additional sizes appear in the Appendix to this report. The specifications will still be in exact accordance with the specifications of the National Board of Fire Underwriters.

In addition, wherever these specifications refer to the Standard Methods of Testing Cotton Rubber-Lined Hose, such references should be changed to the proposed Tentative Methods of Testing Rubber Products, if these be approved.

(*i*) *Tentative Specifications for Commercial Adhesive Tape for Electrical Purposes* (*D 69 - 21 T*).[2]—It is recommended that these specifications be revised as follows:

Change the title of the specifications to read

"Tentative Specifications for Adhesive Tape for General Use for Electrical Purposes."

Section 1.—Change the last sentence to read as follows:

"This tape is for general use for covering electrical insulation applied to wires and cables."

Section 6.—Omit this section, reading as follows, re-numbering the subsequent sections accordingly:

"The compound shall contain not more than 0.05 per cent of free sulfur."

Experience has shown that the test prescribed in Section 7 is sufficient protection against free sulfur.

Section 7.—Change from its present form: namely,

"When the tape is wrapped on a clean, bright, smooth copper rod and baked at 100° C. for 16 hours, the compound shall not discolor the copper."

to read as follows:

"When the tape is wrapped on a clean, bright, smooth copper rod and baked at 100° C. for 16 hours, the copper shall not show the blue-black color characteristic of copper sulfide."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 773 (1921).

[2] *Ibid.*, p. 799.

Section 10.—Change to read as follows by the addition of the italicized words and the omission of the figures in brackets:

"(*a*) The adhesion between adjacent layers of the tape shall be such that when a strip of tape 2 ft. long is taken from a roll and wound upon a mandrel 1 in. in diameter under a tension of 10 lb. per inch of width at a rate of 30 in. per minute, *and allowed to stand for three minutes with the weight attached,* a weight of 4 lb. per inch of width shall not cause the plies to separate at a rate greater than 30 in. per minute.

"*The test shall be made at a room temperature not less than 21.1° C. (70° F.) nor more than 23.9° C. (75° F.), the sample having been kept within these limits for at least 30 minutes immediately preceding the time of testing.*

"*The mandrel shall be so free in its bearings that a weight of 1 oz. will cause it to revolve freely when suspended from a cotton string wound in a single layer on the center of the mandrel.*

"(*b*) After a strip has been exposed to dry air at a temperature of [100° C.] *not less than 99° C. (210.2° F.) nor more than 101° C. (213.8° F.)* for 16 hours and then cooled to room temperature, a test specimen shall withstand the test prescribed in Paragraph (*a*) except that the weight applied to unwind the tape shall be 1⅓ lb. per in. of width instead of 4 lb."

The committee recommends that the specifications as revised be continued as tentative.

(*j*) *Tentative Specifications for Rubber Insulating Tape (D 119 - 21 T).*[1]—It is recommended that these specifications be revised as follows:

Section 5.—The procedure as specified is for a much more complete analysis than is necessary under these specifications. Accordingly, change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"If an analysis of the compound is made, it shall be carried out in accordance with [the Joint Rubber Insulation Committee's Procedure (See Appendix II to the Tentative Specifications for Insulated Wire and Cable: 30-Per-Cent Hevea Rubber (Serial Designation: D 27 - 21 T) of the American Society for Testing Materials)] *Sections 15 to 47, inclusive (Joint Rubber Insulation Committee's Procedure), of the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 - 22 T) of the American Society for Testing Materials, with the following exceptions:*

"(*a*) *Omit 'chloroform extract' from the diagram in Fig. 1 and from the tabulation in Section 45.*

"(*b*) *In place of Section 20 substitute the following: 'Remove the rubber compound from the separator and cut into as thin strips as possible.'*

"(*c*) *Omit Sections 25 and 33.*

"(*d*) *In Section 34, substitute 'acetone' for 'chloroform' in the first and second lines.*

"(*e*) *In Section 38, omit 'from the conductor' in the third and fourth lines.*

"(*f*) *In Section 46, omit 'and chloroform' and substitute 'extract' for 'extracts' in the first sentence. Omit the second sentence.*

"(*g*) *In Section 47, omit 'chloroform extract'.*"

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 802 (1921).

Section 10.—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

"The tape shall conform to the following requirements:

WIDTH, IN.	THICKNESS, IN.	NOMINAL WEIGHT PER ROLL, LB.	MINIMUM NET WEIGHT PER 100 ROLLS, LB.[a]	MINIMUM LENGTH PER POUND, YD.[b]
½..............	[0.035] *0.030*	½	50	[22½] *20¼*
¾..............	[0.035] *0.030*	½	50	[15] *17½*
1..............	[0.035] *0.030*	1	100	[11¼] *13*

[a] Exclusive of core, wrapping and box.

[b] Exclusive of core, wrapping, box and separator.

The committee recommends that the specifications as revised be continued as tentative.

(*k*) *Tentative Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not Exceeding 3000 Volts to Ground* (*D 120 - 21 T*).[1]—It is recommended that these specifications be revised as follows:

Section 9.—Substitute the word "back" for the word "cuff" in the second sentence. Add a sentence to read as follows:

"Indelible and non-conducting ink shall be used."

Section 11.—Change from its present form: namely,

"The manufacturer shall replace, without cost to the purchaser, gloves which at any time within a period of eight months from the date of initial test, fail to pass the tests herein prescribed; provided the gloves have been stored in their original boxes at a temperature not exceeding 75° F."

to read as follows:

"The manufacturer shall replace, without cost to the purchaser, gloves which at any time within a period of eight months from the date of initial test, fail to pass the tests herein prescribed; provided the gloves have been properly stored in their original boxes.

"NOTE.—'Proper storage' is to be interpreted to mean that gloves are not to be stored directly above or in proximity to steam radiators or other sources of artificial heat. It is desirable that the ambient temperature be not in excess of 90° F. (32.2° C.)."

Section 16 (*b*).—Change to read as follows by the addition of the italicized words:

"Measurements shall be made at one or more points in the crotch of thumb and index finger *and in the crotches between the fingers.*"

Section 16 (*c*).—Omit the last sentence, reading as follows:

"A spring rubber gage is particularly well suited to measurements in face and back of glove."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 805 (1921).

Add a new paragraph to read as follows:

"A dial-type micrometer graduated to mils and mounted in a manner similar to that shown in Fig. 1 is particularly convenient for making all of these measurements, especially the crotches. The anvil is about ¼ in. (6.4 mm.) in diameter and the foot of the spindle about ⅛ in. (3.2 mm.) in diameter."

Section 17.—Change the temperature range from "60 to 80° F." to "60 to 90° F."

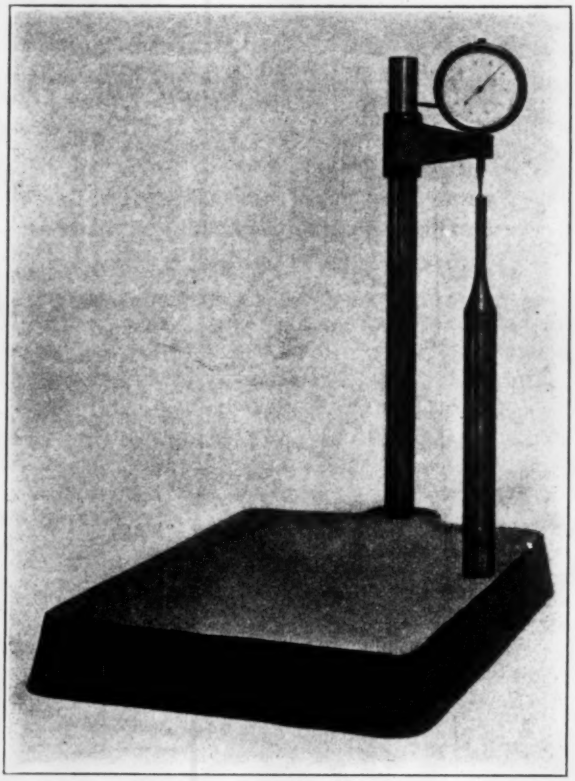

FIG. 1.—Dial Micrometer.

Section 23 (*b*).—Change to read as follows:

"An ammeter in the low tension circuit of the testing transformer. In this case the leakage current shall be determined by noting the decrease in the low tension current when *one glove at a time* is disconnected from the high tension testing circuit, the voltage being left on the test circuit and the remaining gloves in the meantime. The difference in the two currents divided by the ratio will give the leakage current for the glove disconnected from the circuit.

"NOTE.—This method is inaccurate where only one or two gloves are being tested at a time because of the neutralizing effect of the leading current taken by the gloves on the magnetizing current, which is a lagging one. This effect is usually negligible with three or more gloves. The minimum number of gloves which may be safely measured in this manner is easily determined by noting the leakage current of a particular glove when tested with 1, 2, 3, etc., additional gloves, respectively."

In addition, wherever references now appear to the Standard Methods of Testing Cotton Rubber-Lined Hose, they should be changed to the proposed Tentative Methods of Testing Rubber Products, if these be approved.

The committee recommends that the tentative specifications, as revised, be continued as tentative.

PROPOSED NEW TENTATIVE STANDARDS.

Proposed Tentative Specifications for Rubber Pump Valves.—Proposed Tentative Specifications for Rubber Pump Valves are appended to this report[1] and it is recommended that they be published as tentative.

Proposed Tentative Methods of Testing Rubber Products.—Proposed Tentative Methods of Testing Rubber Products have been prepared. These are intended to replace, when adopted, the present Standard Methods of Testing Cotton Rubber-Lined Hose (D 15 - 15)[2] and to provide a more general standard. All of the procedures conform in general to those now given in the Standard Methods of Testing Cotton Rubber-Lined Hose or included in existing tentative specifications. The Joint Rubber Insulation Committee's procedure for complete chemical analysis of 30-per-cent rubber compounds, which now appear as an appendix to the Tentative Specifications for Insulated Wire and Cable (D 27 - 21 T) have been transferred to this proposed tentative method. The methods are appended to this report[3] and it is recommended that they be published as tentative.

MISCELLANEOUS.

Hard Rubber Containers for Storage Batteries.—The committee has considered the advisability of undertaking the preparation of specifications for this material but has decided that there is not sufficient demand for such specifications at the present time.

Weatherstripping.—Investigation of the need for specifications for weatherstripping for railroad cars and buildings disclosed the fact that there is not sufficient demand for such specifications at the present time to justify the expenditure of time which would be necessary to prepare them.

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[1] See p. 944.—ED.

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 947.—ED.

Rubber Gloves.—The Accident Prevention Committee of the National Electric Light Association has requested Committee D-11 to expand the section in our Tentative Specifications for Rubber Gloves for Electrical Workers which deals with dimensions so as to insure a better fitting glove, since this is an important element from a personal hazard standpoint. The committee will undertake to improve our specifications in this respect.

Electrical Switchboard Matting.—A request has been received from the Accident Prevention Committee of the National Electric Light Association to prepare specifications for matting to be used about electrical switchboards and in similar situations where an electrical hazard is involved. The Sub-Committee on Protection of Persons from Electric Shock has undertaken the development of such specifications.

Belting.—The sub-committee dealing with this material is considering changing the shape of the test specimen now specified in our Tentative Specifications for Rubber Belting, and the inclusion of both a maximum and a minimum limit in the stretch test, and is investigating the general problem of the suitability of friction tests as a measure of durability of belts.

Technical Papers.—Two members of this committee are presenting papers at this annual meeting, one entitled "Accelerated Aging Tests of Rubber Goods" by W. W. Evans and one entitled "Methods for Conducting Physical Tests on Rubber Products" by A. H. Nuckolls.

Joint Rubber Insulation Committee.—The Joint Rubber Insulation Committee, whose well-known "Specifications and Analytical Procedure for 30-Per-Cent Hevea Rubber Insulating Compound" have been in extensive use in the industry for several years, went out of existence on July 15, 1921, at which time they passed a resolution requesting that the American Society for Testing Materials take over its work. This responsibility was accepted in due course by the Executive Committee of our Society and turned over to this committee. A Sub-Committee on Chemical Analysis was organized and has in its membership a large number of former members of the Joint Rubber Insulation Committee.

The following is the result of the letter ballot vote of the committee (36 members) on the recommendations made in this report in reference to revisions of standards and submission of new tentative standards:

Items.	Affirmative.	Negative.	Not Voting.
PROPOSED REVISIONS OF TENTATIVE STANDARDS.			
Tentative Specifications for Cotton Rubber-Lined Fire Hose for Private Fire Department Use (D 14 - 21 T)	30	2	4
Tentative Specifications for Commercial Adhesive Tape for Electrical Purposes (D 69 - 21 T)	26	0	10
Tentative Specifications for Rubber Insulating Tape (D 119 - 21 T)	28	0	8
Tentative Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not Exceeding 3000 Volts to Ground (D 120 - 21 T)	25	0	11
PROPOSED NEW TENTATIVE STANDARDS.			
Proposed Tentative Specifications for Rubber Pump Valves	24	0	12
Proposed Tentative Methods of Testing Rubber Products (D 15 - 22 T.)	29	1	6

This report has been submitted to letter ballot of the committee, which consists of 36 members, of whom 33 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. FARMER,
Chairman.

C. B. MARTIN,
Secretary.

EDITORIAL NOTE.

The proposed revision of the Standard Methods of Testing Cotton Rubber-Lined Hose was accepted for publication as a new tentative method entitled "Tentative Methods of Testing Rubber Products" and appears on page 947.

The proposed revisions of the Tentative Specifications for Cotton Rubber-Lined Fire Hose for Private Fire Department Use, of the Tentative Specifications for Commercial Adhesive Tape for Electrical Purposes, of the Tentative Specifications for Rubber Insulating Tape and of the Tentative Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not exceeding 3000 volts to Ground referred to in this report were accepted. The tentative specifications as thus revised appear on pages 925–943.

The proposed Tentative Specifications for Rubber Pump Valves were accepted for publication as tentative and appear on page 944.

APPENDIX.

PROPOSED REVISIONS OF THE TENTATIVE SPECIFICATIONS FOR COTTON RUBBER-LINED FIRE HOSE FOR PRIVATE FIRE DEPARTMENT USE (D 14 - 21 T).[1]

Section 1.—Change to read as follows:

> "These specifications apply to cotton, rubber-lined hose for private use for fire protection purposes. They cover the following sizes: 1½-in. single and double-jacketed; 2-in. single and double jacketed; 2½-in. single, double and triple-jacketed; 3-in. double and triple-jacketed; 3½-in. double and triple-jacketed."

Section 2 (*a*).—Insert the words "or jackets" after the word "jacket".

Section 2 (*b*).—Change the word "jacket" to "jackets" and add a sentence to read as follows:

> "Where more than one jacket is prescribed, they may be separate or interwoven."

Section 3 (*c*).—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "The lining shall be of uniform thickness and not less than [0.058 nor more than 0.072 in. in thickness] *the lower limit nor more than the upper limit given in item* (*b*) *of Table I* exclusive of the backing."

Section 9.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "(*a*) Each length of hose shall be subjected to [a hydrostatic pressure of 300 lb. per sq. in.] *the hydrostatic pressure given in item* (*c*) *of Table I* for five seconds without leaking in the hose or at the couplings or breaking any threads in the jacket.
>
> "(*b*) A 3-ft. sample in every lot of 3000 ft. of hose or less shall, while lying either straight or curved to a radius of 27 in., withstand without failure [a hydrostatic pressure of 500 lb. per sq. in.] *the hydrostatic pressure given in item* (*d*) *of Table I.*
>
> "(*c*) One full length in every lot of 500 ft. of hose or less shall, while kinked, withstand without failure [a hydrostatic pressure of 250 lb. per sq. in.] *the hydrostatic pressure given in item* (*e*) *of Table I* applied for five seconds.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 773 (1921).

Section 10.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The elongation of the hose when tested as prescribed in Section 9 (*a*) shall not exceed [13 per cent of] *the percentage of* the length measured under a pressure of 10 lb. per sq. in. *which is given in item* (*f*) *of Table I.*

Section 11.—Change the first sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

"[The hose shall not twist more than 25 deg. per ft. when] *When* tested as prescribed in Section 9 (*a*), *the hose shall not twist more than the amount given in item* (*g*) *of Table I.*"

TABLE I.

Property.	Size and Number of Jackets.										
	$1\frac{1}{2}$-in.		2-in.		$2\frac{1}{2}$-in.			3-in.		$3\frac{1}{2}$-in.	
	Single.	Double.	Single.	Double.	Single.	Double.	Triple.	Double.	Triple.	Double.	Triple
(*a*) Prescribed internal diameter, in.	$1\frac{1}{2}$	$1\frac{1}{2}$	2	2	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	3	3	$3\frac{1}{2}$	$3\frac{1}{2}$
(*b*) Thickness rubber lining, in.	0.049 to 0.065	0.049 to 0.065	0.049 to 0.065	0.049 to 0.065	0.058 to 0.072	0.058 to 0.072	0.058 to 0.072	0.058 to 0.072	0.058 to 0.072	0.072 to 0.095	0.072 to 0.095
(*c*) Test pressure on every length, lb. per sq. in.	300	400	300	400	300	400	400	400	400	400	400
(*d*) Bursting test pressure (3-ft. samples) lb. per sq. in.	500	600	500	600	500	600	600	600	600	600	600
(*e*) Kink test pressure, lb. per sq. in.	250	300	250	300	250	300	300	250	250	250	250
(*f*) Elongation, per cent.	13	9	13	9	13	9	9	9	9	9	9
(*g*) Twist, deg. per ft.	50	29	50	29	25	15	15	15	15	15	15
(*h*) Rise, in.	7	none	7	none	4	none	none	none	none	none	none
(*i*) Weight, min., lb.	21	..	29	..	40	..	..	..	..	..	..
Weight, max., lb.	..	42	..	58	..	70	86	93	113	115	135
(*j*) Test pressure marking, lb. per sq. in.	300	400	300	400	300	400	400	400	400	400	400

Section 12.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"When subjected to the test prescribed in Section 9 (*a*) the hose shall not rise more than [4 in.] *the distances given in item* (*h*) *of Table I* from the level of the test table or test floor, or warp more than 20 in. from a straight line drawn from center to center of the couplings."

Section 15.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The hose shall have an internal diameter of not less than [$2\frac{1}{2}$ in.] *the diameter ordered* and shall be furnished in lengths averaging 50 ft."

Section 16.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"*The weight of* each 50 ft. length of hose complete with couplings shall [weigh not less than 40 lb.] *be in accordance with the amount given in item* (*i*) *of Table I.*"

Section 18.—Change the last sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The *inside* diameter [through] *throughout the* couplings shall be [2½ in.] *not less than the nominal inside diameter of the hose to which they are connected.*

Section 21.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The weight of *complete* couplings, including [both] male and female *ends, swivel,* and *the* expansion rings, shall be not less than [5 lb.] *the values given in Table II.*"

Insert Table II as follows:

TABLE II.—WEIGHT OF COUPLINGS.

Nominal Diameter, of Hose, in.	Weight, Complete, lb. Single Jacket.	Double Jacket.	Triple Jacket.
1½	1.5	2.0	....
2	2.5	3.0	....
2½	4.0	5.0	....
3	...	8.0	10.0
3½	...	12.0	14.0

Section 22.—Insert the words "swivels of the" between the words "The" and "couplings", and change the dimension "$\frac{1}{8}$ in." to "$\frac{3}{16}$ in." in Paragraph (*a*).

Add a Paragraph (*c*) to read as follows:

"The inside diameter of the gasket and the washers when in position in the couplings shall be not less than the inside diameter of the hose to which the coupling is attached."

Section 23.—Omit the first sentence, reading as follows:

"The threads of hose couplings shall be interchangeable with those in use in the city or town where the hose will be used."

Section 24.—Omit the note.

Section 25.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"Beginning at a point approximately 4 ft. from the couplings, each 50-ft. length of hose shall be stenciled at two places in black indelible letters 1 in. high with the legend "A.S.T.M. Specifications", the name of the manufacturer, the month and year of manufacture and the words ["Tested at 300 lb."] "*Tested at — lb.*", *the pressure stated to be that given in item* (*j*) *of Table I.*"

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS.

Committee D-13 on Textile Materials held two meetings during the past year. Through the courtesy of the Providence Engineering Society both of these meetings were held in that Society's rooms in Providence, the first on October 28 and 29, 1921, and the second on March 3 and 4, 1922. Both meetings were well attended by members and there was a large attendance of guests representing various cotton manufacturing organizations. At the fall meeting, the time was principally taken up in discussion of preliminary reports from the sub-committees. These discussions resulted in recommendations to sub-committees for continuation of the work and complete reports were submitted at the spring meeting.

A great deal of constructive criticism has resulted from the publication in 1921 of the Tentative Specifications for Imperfections and Tolerances for 60-in. $17\frac{1}{4}$-oz. Square-Woven Tire Builder Fabric (D 122 - 21 T)[1] and this matter has been the subject of considerable discussion both by Sub-Committee VI on Imperfections and Tolerances, and by Committee D-13. Important revisions have been made in this tentative standard, and in the revised form in which it is herewith submitted[2] to the Society, under the title "Tentative Specifications for Imperfections and Tolerances for 60-in. $17\frac{1}{4}$-oz. (made of yarn not less than 8 ply) Square-Woven Builder Fabric," to replace the present Tentative Specifications, it was unanimously approved by all members present at the March meeting of Committee D-13.

The standardization of methods for determination of crimp and off square, particularly the expression of results of these tests, is of great importance to manufacturers and consumers of tire fabric. At present there are two methods in use from which the values obtained are at considerable variance with each other. In answer to a questionnaire submitted to the tire fabric and tire industries by a special sub-committee appointed to study this matter, a large majority replied that the method at present recommended by Committee D-13 is being used. This committee therefore recommends that the Tentative Methods of Testing Textiles (D 76 – 20 T)[1] be published for the year 1922 with no other change than the addition to Section 6 of a note describing "Take-up" to read as follows:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 811 (1921).

[2] See p. 967.—Ed.

> "NOTE.—'Crimp' shall not be confused with 'take-up' which is the percentage difference between the yarn length after straightening and the yarn length as it lies in the fabric based on the straightened yarn length. The threads for the 'take-up' test shall be straightened with the same machine used for the 'crimp' test, but for this test it shall be equipped with an extra scale on the dial, in which case the scale shall be plainly marked 'crimp' and 'take-up'."

A great deal of interest was shown by both members and guests in a new principle for a machine for testing fabric with a constant rate of load application described in a paper read at the October meeting by Henry L. Scott. At this meeting Prof. Haven presented a discussion on the mathematics involved in this machine. At the March meeting Mr. Scott exhibited a working machine built on this principle which was constructed at the request of Committee D-13.

Committee D-13 recommends that the following revisions be made in the Tentative Definitions of Terms Relating to Mechanical Fabric (D 123 – 21 T).[2]

Change the title from its present form: namely,

> "Tentative Definitions of Terms Relating to Mechanical Fabric."

to read as follows:

> "Tentative Definitions of Terms Relating to Textile Materials."

Add a new central heading to read as follows:

> "(*A*) Mechanical Fabric."

Section 3.—Change the definition of oil belt duck from its present form: namely,

> "*Oil Belt Duck.*—A closely woven fabric of plied yarns not over No. 8, made in a variety of widths, the weight being based on the square yard."

to read as follows:

> "*Oil Belt Duck.*—A closely woven fabric of plied yarns not over No. 8, made in a variety of widths, usually a 32-oz. fabric, the weight being based on the square yard."

Change the definition of numbered duck from its present form: namely,

> "*Numbered Duck.*—A plain woven fabric of plied yarns ranging from coarse to fine numbers, weight being based on 22-in. width one yard long."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 804 (1920).

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 814 (1921).

to read as follows:

"*Numbered Duck.*—A plain woven fabric of plied yarns ranging from coarse to fine numbers, weight being based on 22-in. width."

Change the definition of army duck from its present form: namely,

"*Army Duck.*—A fabric made in closely woven plied yarns, weight being based on 28½-in. width."

to read as follows:

"*Army Duck.*—A closely woven fabric of plied yarns usually ranging between 7 to 12 oz., the weight being based on 28½-in. width."

Add a new Section 4 including six new definitions under the new central heading "(*B*) Cotton Fabrics Other than Mechanical Fabrics," to read as follows:

"4. *Twill.*—A weave which produces pronounced lines running diagonally across the fabric, some of which are known as follows:

(*a*) *Drills*—A commercial term for a fabric with warp face twill usually made with three harnesses and single yarns.

(*b*) *Alberts.*—A commercial term for a fabric with filling face usually made with four or five harnesses.

(*c*) *Jeans.*—A commercial term for a fabric with warp face twill like a drill but with higher count and finer yarns.

(*d*) *Serge.*—A commercial term for a fabric of twill weave made with four harnesses 2 by 2.

(*e*) *Clay.*—A commercial term for a fabric similar to a serge but made with six harnesses 3 by 3."

Partly because of the great variety of products produced by textile manufacturers and partly because of lack of appreciation of the advantages which could be obtained through the use of test methods common to the seller and buyer there has been and still is a very noticeable lack of standardization on the part of textile manufacturers in the testing of their products. Obviously the benefit to be derived from a set of standard test methods by manufacturers and consumers depends upon the extent to which they are used, and Committee D-13 has been constantly faced with the problem of making the use of its test methods more general. During the past year considerable work has been done to acquaint textile manufacturers with the Society's standards, and recommendations have been made to the Executive Committee of the Society regarding the endorsement of the Standard General Methods for Testing Cotton Fabrics (D 39 – 20 T) by textile associations.

To fill the need for the development of standards relating to hose and belt ducks, a new sub-committee has been appointed which includes representatives of several of the largest manufacturers and consumers of these fabrics.

During the past year twelve new members have been enrolled in Committee D-13.

Committee D-13 submits to the Society one new standard, the Tentative Methods of Testing Cotton Fibers, appended hereto,[1] for publication as tentative, and three revisions of present tentative standards. These have been submitted to letter ballot of the committee consisting of fifty-one members, with the following results:

Items.	Affirmative.	Negative.	Not Voting.
Submission of Proposed Tentative Methods of Testing Cotton Fibers	40	2	9
Revision of the Tentative Specifications for Imperfections and Tolerances for 60-in. 17¼-oz. Square-Woven Tire Builder Fabric (D 122 – 21 T)	39	2	10
Revision of the Tentative Methods of Testing Textiles (D 76 – 20 T)	42	1	8
Revision of the Tentative Definitions of Terms Relating to Textile Materials (D 123 – 21 T)	41	0	10

This report has been submitted to letter ballot of the committee, which consists of fifty-one members, of whom 40 have voted affirmatively, none negatively, and 11 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. E. JURY,
Chairman.

G. W. SKIRM,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Tentative Specifications for Imperfections and Tolerances for 60-in. 17¼-oz. Square-Woven Tire Builder Fabric, of the Tentative Methods of Testing Textiles and of the Tentative Definitions of Terms Relating to Textile Materials were accepted. The tentative standards as thus revised appear on pages 967, 971, and 976, respectively.

The proposed Tentative Methods of Testing Cotton Fibers were accepted for publication as tentative and appear on page 973.

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[1] See p. 973.—ED.

REPORT OF COMMITTEE E-1

ON

METHODS OF TESTING.

In its annual report a year ago, Committee E-1 on Methods of Testing reviewed briefly the history of the preparation of methods of testing in the Society and outlined the conditions which led to its reorganization by the Executive Committee through the formation of an Advisory Committee of seven "members-at-large" and the representation of all standing committees through the appointment of one or two "representative members." The general plan of conducting the committee's work, as provided in the Regulations Governing Methods and Instruments of Testing drawn up jointly by the Executive Committee and Committee E-5 on Standing Committees, was outlined in some detail.

Since the last annual meeting the Advisory Committee has held three meetings: October 12, 1921, November 18, 1921, and February 17, 1922. The meeting of the main committee scheduled for November was cancelled, and a regular meeting was held February 17, 1922. The Advisory Committee and the main committee will meet again during the present annual meeting.

The Executive Committee has appointed W. H. Fulweiler as a member of the Advisory Committee to succeed A. V. Bleininger, resigned.

The Regulations Governing Methods and Instruments of Testing and also the Rules Governing Committee E-1 on Methods of Testing (the latter prepared and adopted by the committee to govern the details of its procedure) will be printed in the current Year Book.

At the suggestion of the Executive Committee, Committee E-1 brought to the attention of each standing committee during the year the importance of devoting careful attention to the development of methods of testing, pointing out that this is one of the primary objects of the Society. It is gratifying to note that the preparation of methods of test by the standing committees during the year has been quite stimulated and that there will be presented at this annual meeting a number of new methods or extensive revisions of existing methods in several important fields of the Society's work.

Procedure in Considering Methods of Test.—The first task undertaken by the committee following the last annual meeting was a general review of the various methods of test in existing standards and tentative standards, including those published separately as such and those included as parts of specifications. It was considered desirable to limit this study first to methods that are tentative. A complete list of such tentative methods was prepared by the Secretary and submitted at the October meeting of the Advisory Committee, the list comprising 34 methods published as such and 25 methods appearing in tentative specifications. The Advisory Committee carefully discussed the procedure that should be followed by Committee E-1 in the consideration of these methods. The magnitude of the task before us showed the necessity for a carefully prepared method of procedure to be followed by Committee E-1 in the consideration not only of these existing methods but also of new methods which under the regulations must come before Committee E-1 before they can become standard. It was the consensus of opinion of the Advisory Committee that the real function of Committee E-1 is to study methods from the broad viewpoint of the test as a type of test that may be made upon a wide variety of materials. To illustrate: Among the present tentative methods there appear compression tests of concrete, of portland cement mortars, of clay sewer brick, of hollow building tile, of molded insulating materials, and of electrical porcelain; in addition, the compression test has already been applied to materials for which we have standard specifications. It seemed to the Advisory Committee that Committee E-1 should formulate fundamental considerations that would govern compression testing in general, pointing out certain special considerations to be observed in applying the test to specific materials; and that similar studies should be made of other tests, such as tension tests, transverse tests, tests for consistency, plasticity, absorption, distillation, and others. The Advisory Committee accordingly designated Messrs. W. H. Fulweiler and A. T. Goldbeck as a sub-committee of two to report an acceptable procedure to be proposed to the whole committee providing for the consideration of the Society's methods of test along these fundamental lines. This sub-committee presented a report of progress at the November meeting of the Advisory Committee and a final report at the February meeting of that committee, at which the report was adopted and referred to the main committee at its February meeting for action. At this meeting the report was accepted as an expression of the policy of Committee E-1 in carrying out its review of the methods of test of the Society, and the report was referred to letter ballot vote of the committee.

This report is given in full below, and the result of the letter ballot vote of the committee is as follows: Advisory Committee, 8 affirmative, none negative; Standing Committees, 28 affirmative, 1 negative, 6 not voting, total 35.

STATEMENT ON PROCEDURE IN CONSIDERING METHODS OF TESTING.

Your Sub-Committee on Proposed Procedure regarding the formation of sub-committees of Committee E-1 begs to report as follows:

Committee E-1 is now faced with a practical test of the feasibility of its rules and regulations in the task of reviewing the tentative standards that are now before it. The mechanism within the Committee for handling this work is provided for in Article V, Section 1:

> "A method of test referred by a standing committee to Committee E-1 for consideration and advice shall be referred to a sub-committee, appointed by the Advisory Committee, consisting of at least one Representative Member from each standing committee affected by the method of test and a member of the Advisory Committee, who shall be chairman of the sub-committee. The report of this sub-committee will be received and considered by the Advisory Committee and submitted to Committee E-1. If the report of the sub-committee is unanimous, the Advisory Committee may at its discretion refer the method to letter ballot of Committee E-1 without first presenting it at a meeting of Committee E-1."

Two rather different interpretations could be made of this regulation depending upon the policy of the committee in handling the consideration of the tentative standards. One method of procedure would be to form the sub-committee of those associate members whose committees were directly affected or interested in the standard under consideration, and after such a sub-committee had reported to discharge it. This method would apparently result in the formation of a very large number of short-lived committees.

As a result of considerable thought and discussion, your sub-committee has arrived at a rather different conception of the spirit in which this rule should be interpreted to the end that a much broader policy might be adopted with regard to the formation and functioning of these sub-committees. This may be briefly outlined as follows:

That a sub-committee shall be formed to consider each of the general tests such as compression, tension, bending, distillation, etc. It would be the duty of these sub-committees to consider their subject in the broadest manner, studying the fundamentals, suitable apparatus, the application of the test to various materials, and eventually formulating general methods for making the various tests. Such general methods when finally perfected, would discuss the meaning of the test, the fundamental precautions to be observed, apparatus, calibration, accuracy, tolerances, and modifications that may have to be adopted for handling various materials. The general principles thus formulated by the sub-committee of Committee E-1 would then serve as standards to be followed by standing committees in the application of the test in question to their particular materials.

Each sub-committee would be expected, therefore, to make a review of its subject and to bring in its final results in a standardized form that would cover a number of the essential points that are now lacking in many of our existing standards. Such sub-committees would be more or less permanent and would in accordance with our rules be under the chairmanship of a member of the

Advisory Committee. The other members would be the Representative Members or their representatives of the various standing committees who are interested in tests handled by the particular sub-committee, the idea being that the men most conversant with the test in question would represent the regularly elected representative members if necessary on the sub-committees.

It is believed that in this manner the work of correlating the various standards would be most advantageously handled, as a new tentative standard would automatically go to the sub-committee handling that particular subject. It will, no doubt, be necessary to handle certain standards or special tests by small temporary committees, as under the previously described first plan.

It may be objected that such policy of studying the theory and fundamental principles would delay the consideration of existing tentative standards. There seems little reason to believe that this will occur. As a matter of fact, the sub-committees for the first year or so, after a general consideration, would probably approve the method for adoption, indicating that they have not completed their final studies.

It would appear that this policy would involve fewer sub-committees with subsequent easier administration; that with a more stable organization, the work would go forward more efficiently and the sub-committees would have represented all the available knowledge on their general subject from a variety of different angles.

Finally, it is believed that in this matter, Committee E-1 would be fulfilling its duty, to quote from the instructions from the Executive Committee:

"To perform such other functions as may advance, improve, standardize and unify the science of materials testing."

Respectfully submitted,

A. T. GOLDBECK,
W. H. FULWEILER.

In presenting this report to the Society as an expression of the spirit in which its regulations should be interpreted, the committee desires to emphasize that every endeavor will be made, in carrying out the plan of fundamental study of the various kinds of tests, to act as promptly as possible upon tentative methods of test as they are submitted from time to time by the standing committees. It is not the intention of the committee to withhold indefinitely approval of tentative methods that standing committees may desire to see advanced to the status of standard, pending a complete study of fundamental principles underlying the various kinds of tests that may be involved in a particular tentative method. Where the circumstances seem to justify it, it is expected that the sub-committees to be organized under the procedure outlined above could consistently recommend the advancement of a tentative method to standard after due consideration of the special features involved in the method, indicating that the final studies of fundamental principles are not completed and reserving the privilege of suggesting modifications that may seem desirable as their studies progress.

Under the regulations the responsibility for developing methods of testing rests with the standing committees themselves. There can only be one reason for providing for review of these methods by Committee E-1—namely, a reasonable uniformity and continuity of policy in the development of methods of determining properties or characteristics of all materials to which the several methods may properly be applied. This requires cooperation among all the standing committees which may be at work on any given method or type of test, and Committee E-1 becomes the medium through which such cooperation may be accomplished. We cannot too strongly emphasize the necessity that each standing committee which finds it necessary or desirable to develop a method of test, realize that other standing committees may also have found it necessary to determine the same or a similar characteristic of another material and that all will be helped in their work by the broader perspective obtained from cooperative work among all the committees confronted with the similar problem concerning the several materials.

Essentially, Committee E-1 is planning for the future and hopes to lay foundations upon which reasonably permanent structures may ultimately be erected. This will require time and in the meantime orderly progress of work may not be stopped or even unduly delayed. Each technical committee is represented upon Committee E-1 and is in a position, therefore, to assist in reaching a decision best calculated to serve in each individual case as it arises. It is obvious that there may be approved many methods as tentative and even as standard which will require modifications as further knowledge and experience are gained from the work of Committee E-1 along fundamental lines.

Classification of Methods of Test.—To facilitate the development of the work of the committee along these lines, an analysis and tabulation of all the methods of test of the Society, both standard and tentative, was made in the office of the Secretary. A complete list of all tests was first prepared. It was found that by grouping together tests of a similar nature the entire list could be classified in sixteen divisions such that each division contained those tests that seem to be fairly closely related. The complete tabulation is quite extensive (85 typewritten pages) and will be of considerable assistance to the committee in making the general review of the Society's methods that the committee is about to undertake. The tabulation is too extensive to publish, but some idea of its magnitude can be obtained from the following list of the kinds of tests that are specified in the Society's standards and tentative standards, these having been grouped under the sixteen divisions as previously mentioned.

CLASSIFICATION OF METHODS ACCORDING TO TYPE OF TEST.

I. Mechanical Tests made by Application of Stress-producing Forces. (See also II.)
  - Tension.
  - Compression.
  - Crush.
  - Flattening.
  - Bend.
  - Fracture.
  - Homogeneity.
  - Flange.
  - Splitting.
  - Hydrostatic.
  - Brinell Hardness.
  - Impact.
  - Abrasion.
  - Friction.
  - Beading.

II. Mechanical Tests Involving such Properties as Consistency, Plasticity, etc. (Closely related to I.)
  - Consistency.
  - Plasticity.
  - Workability.
  - Viscosity.
  - Ductility.
  - Softening Point.
  - Melting Point.
  - Penetration.

III. Tests for Density, Refractive Index and Similar Physical Constants. (See also V in relation to Porosity.)
  - Density and Specific Gravity.
  - Unit Weight.
  - Refractive Index.

IV. Classification of Material. (Including separation of materials, impurities, etc.)
  - Mechanical Separation.
  - Percentage of Waste.
  - Colorimetric Tests.
  - Determination of Foots.
  - Precipitation Number.

V. Tests for Absorptive Properties. (See also III.)

VI. Tests for Determination of Water.

VII. Tests for Constancy of Volume.

VIII. Tests for Time of Setting.

IX. Thermal Tests.
  - (Cast Iron Wheels.)
  - Chill Test.
  - Fire Tests of Materials.
  - Freezing and Thawing.
  - Spalling Action.
  - Slagging Action.
  - Fusion.
  - Fusibility.
  - Cloud and Pour Tests.
  - Heating Test (jellying of Tung oil).
  - Digester Test.

X. Test for Volatility.
  - Distillation.
  - Loss on Heating.
  - Flash and Fire Point.

XI. Metallographic Tests.

XII. Magnetic Tests.

XIII. Dielectric Tests.

XIV. Miscellaneous Tests of a Chemical Nature.
  - Free Carbon.
  - Soluble Bitumen.
  - Matter Insoluble in Benzol.
  - Alcohol Insoluble Matter.
  - Carbon Residue.
  - Determination of Ash.
  - Free Sulfur.
  - Discoloration of Copper.
  - Tinning Test.
  - Iodine Number.
  - Polymerization.
  - Determination of Acid.
  - Saponification Number.
  - Unsaponifiable Matter.
  - Strain Test.
  - Determination of Rosin.

XV. Color.

XVI. Dimensional Measurements.
  - Measurements.
  - Crimp and Off-square.

With the adoption of the procedure above outlined and with the above classification of the Society's methods, the committee has mapped out its program of work along these lines and reports the following progress, the reports being arranged for convenience in the order of the above sub-divisions:

I. Methods of Mechanical Tests Made by Application of Stress-Producing Forces.—As mentioned in the last annual report, the revision of the Society's Standard Methods for Mechanical Testing of Metallic Materials (E 1 – 18) has been placed in the hands of a sub-committee of Committee E-1, under the chairmanship of H. F. Moore, consisting of the representative members of Committee E-1 from those committees dealing with metals. It has been decided to refer the tests classified in Group I to this sub-committee, which will be suitably enlarged by representatives of committees of the Society dealing with other materials than metals which are subjected to the kinds of tests there classified. It is believed that the revision of the methods of testing metals which is now actively under way, and which is mentioned in detail later in this report, will go far towards establishing fundamental principles to be observed in making the kinds of tests listed in this group. Three tests in this group that are of wide application to many types of materials are the tension, compression and bend (or transverse) tests, and it is the expectation that the work of this sub-committee will lead to a description of the fundamentals of these tests as applied to any material that will be of the greatest possible service to all who are concerned with the testing of materials.

The thermal test for cast-iron wheels and the chill test for cast-iron wheels and cylinders (Group IX) have also been assigned to this sub-committee because of their special application to metals.

II. Methods of Mechanical Tests Involving such Properties as Consistency, Plasticity, etc.—This group of tests has been referred to a representative sub-committee under the chairmanship of A. T. Goldbeck. This sub-committee was originally organized to consider certain physical tests of such cementitious materials as cement, lime, gypsum, etc. Certain of the properties in this group, that is, those designated by the terms "consistency," "plasticity" and "workability," are especially applicable to cementitious materials, and the sub-committee with representatives from a few additional committees was readily made sufficiently representative to include related properties of viscosity, softening point, melting point, penetration and ductility. The deliberations of this sub-committee have brought out clearly that there is considerable confusion in the use of these terms and that one of the first essentials in the committee's work would be to arrive, if possible, at acceptable definitions of the terms and a description of the properties of materials that they denote. For example, a discussion of the term "consistency" brought out several ideas of the meaning of this term: namely,. That consistency is a measure of the degree of wetness of a material; that it is a measure of the resistance of a material to change of form; and that consistency depends primarily upon the dispersion of the solid particles in a liquid medium.

To assist the sub-committee in its work there was prepared in the Secretary's office a "Memoranda on Definitions of and Tests for Consistency, Plasticity, etc., as Appearing in A.S.T.M. Publications." This memoranda summarizes all available information in the Society's standards and tentative standards relating to the terms in this group, which are found in the standards relating to cement, lime, gypsum, bituminous materials, petroleum products, insulating varnishes and fire-clay brick (in all, 20 methods). Definitions of the terms found in standard dictionaries and as prepared by committees of the Society are first given, followed by an abstract of the methods of determining the properties as described by the several committees. These are followed by abstracts from reports, papers and discussions in the Society's Proceedings over the last ten years, illustrating the usage of these terms in current engineering literature. The entire document of 20 typewritten pages summarizes the work that the Society has so far done in specifying methods for determining these several properties, and will serve well as a starting point for the work of this sub-committee. About 200 mimeographed copies of the memoranda have been distributed among the officers of the standing committees interested, the chairmen and members of the sub-committees of those standing committees dealing with methods of testing and nomenclature, and other individuals whose opinions will be of value to the sub-committee.

III. Methods of Tests for Density, Refractive Index and Similar Physical Constants.—Pending the preparation of fundamental definitions of "density" and "specific gravity,"—a matter that is now receiving the consideration of Committee E-8 on Nomenclature and Definitions,—Committee E-1 has deferred any consideration of the methods in the Society's standards and tentative standards for determining the properties classified in this group.

IV. Methods for Classification of Material (Including Separation of Materials, Impurities, etc.).—The principal test in this group is that of mechanical separation of materials, including the grading of material and the determination of fineness. Progress has been made in the organization of a sub-committee to consider these tests.

V. Methods of Tests for Absorptive Properties.—Progress has been made in the preparation of a resumé of the Society's tests for absorptive properties.

VI. Methods of Tests for Determination of Water.—A sub-committee has been formed under the chairmanship of W. H. Fulweiler, which is considering the harmonizing of methods for determining water in certain bituminous materials and petroleum products, the three committees involved being D-2 on Petroleum Products and Lubricants, D-4 on Road Materials, and D-7 on Timber. Progress can be reported in the study of the methods in the charge of these three committees, and the sub-committee will be suitably enlarged to consider similar tests of other committees.

VII. Methods of Tests for Constancy of Volume.—Progress has been made in the preparation of a resumé of the Society's tests for constancy of volume.

VIII. Methods of Tests for Time of Setting.—Progress has been made in the preparation of a resumé of the Society's tests for time of setting.

IX. Methods of Thermal Tests.—The tests in this group are for the most part highly special and the several tests are usually of interest to but one or two committees. The tests are being reviewed by the Advisory Committee, particularly with respect to the clarity of description and the general form and arrangement.

X. Methods of Tests for Volatility.—The tests in this group have been referred to a sub-committee under the chairmanship of A. W. Dow. This sub-committee was mentioned in the last annual report as having been organized to review the several distillation tests that have been proposed by the various committees of the Society, unifying them in any respect that would not detract from their value and suggesting modifications for their betterment. One of the first features brought out in the work of this sub-committee was the fact that it appeared the distillation thermometers could be unified; but since the standardization of thermometers concerned a number of other tests it was considered advisable to recommend to the Executive Committee of the Society the organization of a new standing committee on thermometers. This recommendation was approved by the Executive Committee and Committee D-15 on Thermometers was organized in October, 1921, and has taken over the problem of standardizing thermometers required in A.S.T.M. tests.

The sub-committee then discussed the unifying and simplifying of other apparatus used in the distillation test, but it was soon realized that there have not been made a sufficient number of investigations comparing the several different methods to enable reliable conclusions to be formed. It was therefore thought advisable to investigate the various distillation methods by sending out standard samples of various materials for collaborative work, testing the materials not only by the method standard for those materials but by other methods designed for different classes of material. This collaborative work is now well under way with at least three of the standing committees represented and it is hoped that considerable data will be available within the next year upon which the sub-committee can base some accurate conclusions as to the effect of different apparatus and different methods of procedure on the results obtained.

The sub-committee has also given consideration to the various tests for flash point that are standard or tentative in the Society at present. These are the Standard Methods of Test for Flash Point of Volatile Flammable Liquids (D 56 – 21),[1] Tentative Method of Test for Flash and Fire Points by Means of Open Cup (D 92 – 21 T),[2] Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 21 T)[3] and Tentative Methods of Testing Insulating Varnishes (D 115 – 21 T).[4] The sub-committee has reviewed these methods and reports that the descriptions are satisfactory as to wording and form. The sub-committee has recommended that Committee E-1 approve the recommendation of Committee D-2 on Petroleum Products and Lubricants, made at the present annual meeting, that the Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 – 21 T) be referred to letter ballot of the Society for adoption as standard, revised as recommended by Committee D-2 in its annual report. The sub-committee has recommended to Committee D-9 on Electrical Insulating Materials that the Tentative Methods of Testing Insulating Varnishes (D 115 – 21 T) be revised by stating more specifically the method of flash test that would be best suited to the insulating varnishes being tested. The sub-committee has also suggested that Committee D-2 investigate the possibility of adapting the Tag Closed Tester to high-flash volatile products with the thought of adopting it, if possible, as a single standard closed flash tester.

During the coming year this sub-committee will take under consideration other tests for volatility falling in this group.

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[1] 1921 Book of A.S.T.M. Standards, p. 669.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[3] *Ibid.*, p. 655.

[4] *Ibid.*, p. 722.

XI. Methods of Metallographic Tests.—The preparation of all metallographic tests has been referred to Committee E-4 on Metallography. Methods of Metallographic Testing of Iron and Steel (E 3 - 21 T)[1] were proposed at the last annual meeting and accepted as tentative and Committee E-4 is now engaged in the preparation of methods of metallographic testing of non-ferrous metals.

XII. Methods of Magnetic Tests.—The preparation of these methods has been referred to Committees A-6 on Magnetic Properties and A-8 on Magnetic Analysis.

XIII. Methods for Dielectric Tests.—These tests occur exclusively in the methods prepared by Committees D-9 on Electrical Insulating Materials and D-11 on Rubber Products. These committees have stated to Committee E-1 that the dielectric strength tests described in the methods and specifications in the charge of these two committees are in conformity with the recommendations in the standardization rules of the American Institute of Electrical Engineers wherever the latter apply. These tests are of very special application and are being reviewed by the Advisory Committee for their form and clarity of expression.

XIV. Methods for Miscellaneous Tests of a Chemical Nature.

XV. Methods for Determination of Color.

XVI. Methods for Certain Dimensional Measurements.

The tests in these three groups are for the most part highly special and the several tests are usually of interest to but one or two committees. The tests are therefore being reviewed by the Advisory Committee, particularly with respect to the clarity of description and the general form and arrangement.

It is believed that considerable progress will be made in the consideration of these and other special tests during the coming year.

Revision of Standard Methods of Mechanical Testing of Metallic Materials (E 1 - 18).—The sub-committee (previously referred to) in charge of this revision, under the chairmanship of H. F. Moore, has made substantial progress during the past year. Since the last annual meeting two well-attended meetings of the sub-committee have been held and considerable correspondence has passed between the members. As the result of the activities of this sub-committee, Committee E-1 includes in an appendix to this report revisions of the section on definitions in the standard methods, and of the section on calibration of testing machines. The committee is not yet prepared to recommend these revisions for publication as tentative but wishes to submit them as a report of substantial progress in this undertaking.

The section on definitions has been extended to include terms not heretofore defined in the standard methods. Typical stress-strain diagrams are shown and methods of plotting them described. Elastic limit and yield point are defined and the definitions are supplemented with a description of methods of determining these properties. Attention is called to the fact that the sub-committee in charge of this work has concluded that experience does not indicate any appreciable difference between the elastic limit and the limit of proportionality of stress to strain (sometimes called the proportional limit) and that therefore the determination of the unit stress at the limit of proportionality of stress to strain is to be regarded as an accurate determination of the elastic limit.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 817 (1921).

The section on calibration of testing machines has been entirely rewritten and enlarged. It is appended hereto under the provisional title "Methods for Verification of Testing Machines."

Committee E-1 particularly solicits criticism and discussion of these progress reports. During the coming year the committee will consider all comments received and will continue its work in the revision and extension of the present standard methods.

Advancement of Method of Test for Flash Point to Standard.—In pursuance of the recommendations of the Sub-Committee on Volatility referred to above, Committee E-1 has approved the recommendation of Committee D-2 on Petroleum Products and Lubricants that the present Tentative Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester (D 93 - 21 T) be referred to letter ballot of the Society for adoption as standard with the revision that is recommended by Committee D-2 in its annual report.

The letter ballot vote of Committee E-1 on this recommendation is as follows: Advisory Committee, affirmative, 7; negative, 0; not voting, 1; total, 8; Standing Committees, affirmative, 20; negative, 0; not voting, 15; total, 35.

Suitability Tests.—In its last annual report the committee briefly called attention to the two kinds of tests of materials that are made: (1) Control tests, to determine whether a given material or product conforms to specified requirements; and (2) Suitability tests, to determine whether the material or product is entirely suitable for the purpose intended. During the past year this subject was referred to a special committee with instructions to prepare a statement that could be sent out to the standing committees for their consideration. Such a statement was received at the meeting of the committee held during the 1921 annual meeting and is given below:

REPORT OF SUB-COMMITTEE ON SUITABILITY TEST METHODS.

Your sub-committee appointed to consider the importance of special test methods devised to determine the suitability of materials believes that service or suitability tests are generally necessary, and whereas most of the tests now in use should be classed as control tests, it is important that further methods be provided for testing suitability of materials. It is, therefore, believed to be important to recognize this necessity and to provide test methods for this purpose. The following descriptions of control tests and suitability tests indicate your sub-committee's conception of the functions of these tests:

Control Tests are applied to materials to determine certain definitely required qualities in terms which will allow of comparison with standards that have been predetermined. The application of a control test assumes the existence of a specification or of a known standard. Control tests are tests which may be applied by both the manufacturer and consumer of the material being tested.

Suitability Tests are applied to determine the ability of materials to perform properly the functions required of them as component parts of structures or articles of manufacture. The principal basis on which suitability tests should be developed is service required. Suitability tests may be:

1. Actual service tests of a finished article under actual conditions;
2. Tests of certain qualities in the finished product based on knowledge that certain values in the finished product indicate definite values in the material under observation;
3. Tests of certain qualities in material under observation, the values of which have been previously determined in their relation to the actual service of the finished product.

Suitability tests do not assume the presence of specifications or acknowledged standards, but they should be of such nature that they will guide the consumer of the raw material in the acceptance of an unknown product. They are not necessarily tests which can be carried out by the manufacturer of the raw product. They are of greatest interest to consumers, although it necessarily follows that even in cases where these tests are such that they cannot be carried out by manufacturers of the materials to be tested, the manufacturers are, nevertheless, vitally interested in suitability tests to which their products are to be subjected and the values which are required of them.

In many cases it would not seem practicable for a standing committee to draw up specific tests for the suitability of the product with which it has to deal because of the variety of finished products into which the materials enter. In such cases it would probably be desirable for the standing committee to go no further than to establish certain limits within which all suitability tests must be conducted. Some standing committees, however, may find it entirely practicable to definitely establish suitability tests.

Your sub-committee makes the following recommendations:

1. That two general classes of test methods be recognized:
   - (*a*) *Control Test Methods* to determine qualities of materials in terms which will allow of comparison with predetermined standards;
   - (*b*) *Suitability Test Methods* to determine the ability of material to properly perform the function required of it as a component part of a structure or article of manufacture.
2. That all standing committees be asked to consider the advisability of developing suitability tests for the material under their consideration; and
3. That where research work is required for the development of these test methods, steps be taken for enlarging the personnel of the various committees so that necessary research work may be

carried out, and when such action is necessary it is recommended that the standing committees appoint sub-committees to which this work may be delegated.

Respectfully submitted on behalf of the sub-committee,

A. E. JURY,
Chairman.

This report has been sent to each standing committee with the request for comments and expressions of opinion regarding its applicability to the work of the standing committees. Several committees have submitted replies and it is expected to receive many others during the coming year.

Methods of Reporting Mean Results.—Committee E-1 has received from Committee D-4 on Road Materials the following resolution pointing out the desirability of considering methods that are used in arriving at average results to be reported from a series of tests:

RESOLUTION PASSED BY COMMITTEE D-4 AT ITS MEETING MARCH 30, 1921.

Committee D-4 on Road Materials wishes to call the attention of Committee E-1 to certain facts in connection with methods of testing that it believes are of very considerable importance, not only to Committee D-4 but to many of the other standing committees, and on which it desires assistance and advice.

In carrying on many of the tests, repeated results on apparently the same sample of material vary quite widely from the mean. It has been common practice in reporting the final result, which is usually an arithmetical mean, to eliminate those results which appear to be abnormal and, as a matter of fact, some of our specifications call for the elimination of abnormal results from the reported mean.

It is felt desirable that study should be made of this matter with a view to

1. Establishing some criterion to determine what is the mean result in order that abnormal results may be eliminated;
2. To consider the best method of expressing the final result; and
3. To consider in view of the requirements of the various tests the number of observations that should be made in order to arrive at representative figures.

Committee E-1 believes that this subject merits consideration and as the first step the resolution has been brought to the attention of each of the standing committees for their comment. Several such comments have been received and will be considered during the course of the year in conjunction with others that are expected. Attention is called to the interesting discussion of this subject in the report this year of Committee C-8 on Refractories.

Impact Testing.—Committee E-1 has given considerable thought during the year to the subject of impact testing. A special committee consisting of Messrs. T. D. Lynch, chairman, W. H. Bassett, A. N.

Johnson and Richard Moldenke fully reviewed a considerable amount of data that had been received from the British Engineering Standards Association.[1] The committee felt that the importance of this subject warranted a general discussion at the annual meeting and appointed a special committee under the chairmanship of Mr. Lynch to work out the details of such a symposium in cooperation with the Committee on Papers and Publications. It is believed that this discussion will not only bring out interesting and valuable information but will be of much aid in developing the further work of the Society in the study of the impact test.

Form of Methods of Test.—The committee stated in its report a year ago that it had prepared a suggested outline of the form in which a method of test should preferably be arranged. This report was submitted to Committee E-5 on Standing Committees for its consideration, with the recommendation that it be made a part of the Regulations Governing the Form of Standards. This recommendation was subsequently approved by Committee E-5 and the revised Regulations were sent to the officers of all standing committees and have been of considerable value to the committees in the arrangement of new and revised test methods being reported at this annual meeting. The revised Regulations will appear in the current Year Book.

As related somewhat to this subject, the committee wishes to call attention to the fact that occasionally specific methods of test are reported by committees as a part of specifications or of certain general methods in such a way that their significance may be lost sight of and it may be difficult to locate them in the Society's publications. The committee suggests that wherever possible standards shall be so edited that the various methods of test stand out clearly and in such a way that if occasion demands, the test may be published separately as of general application.

In conclusion, the committee feels that its work has been started along sound, fundamental lines and that it is now in a position to make more rapid progress in the consideration of the various methods of test that are before the Society. The cooperation of the standing committees through their representative members is essential and the committee, expressing its appreciation of the cooperation during the past year, earnestly solicits their continued support. In order to pass intelligently upon a method of test submitted to it by a standing committee, it is very desirable to know the basis upon which the given method has been developed; and the committee therefore suggests to all standing committees that in presenting methods of test, the data on which the methods are based be also given, in such form that all who are interested will have access to it. It is certain that this will greatly facilitate the work of the committee and will add to the interest and value of the reports of the standing committees.

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[1] This review was presented in abstract at the Symposium on Impact Testing of Materials. See Part II of the *Proceedings*, p. 100.—ED.

This report has been submitted to letter ballot of the committee with the following result: Advisory Committee, affirmative, 7; negative, 0; not voting, 1; total 8; Standing Committees, affirmative, 29; negative, 0; not voting, 6; total, 35.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

C. L. WARWICK,
Ex-Officio Secretary.

EDITORIAL NOTE.

For a discussion of this report, see page 528.

SUGGESTED DEFINITIONS RELATING TO METHODS OF TESTING.

A REPORT OF PROGRESS IN THE REVISION OF THE STANDARD METHODS OF MECHANICAL TESTING OF METALLIC MATERIALS (E 1 - 18).

Tension exists in a body which is subjected to axial forces which tend to pull the body in two.

Compression exists in a body which is subjected to axial forces which tend to shorten the body.

Shear exists in a body which is subjected to forces which tend to cause two contiguous parts to slide relatively to each other in a direction parallel to their plane of contact.

Flexure exists in a body which is subjected to forces which tend to change the curvature of the axis of the body.

Torsion exists in a body which is subjected to forces which tend to cause rotation about the axis of the body of a cross-section with reference to a contiguous cross-section.

Stress is the internal force which, in the presence of forces causing a change of form of a body, tends to hold the particles in their original relation and to preserve the integrity of the body. Stress, in the strict sense of the term, is a quantity which is measured in pounds (kilograms). *Unit stress* is the stress per unit of area at any given location on a section of a body, and is measured in pounds per square inch (kilograms per square millimeter).

The term "stress" is frequently used when, strictly, the term "unit stress" should be used. Probably this use of the term "stress" rarely causes serious confusion. There are three kinds of stress: tensile, compressive, and shearing. Flexure involves the combination of tensile stress and compressive stress. Torsion involves shearing stress.

Strain or *Deformation* is the change in any linear dimension of a body, which change accompanies a given stress. Strain is measured in inches (millimeters). *Unit strain* or *unit deformation* is the change per unit of length in any linear dimension of a body, and is measured in inches per inch of length (millimeters per millimeter).

Under tensile stress or compressive stress, strain is measured along the dimension under consideration. Shearing strain is measured at right angles to the dimension under consideration. In torsion tests, which involve shearing stress, it is customary to measure the angle of twist, which may be translated into terms of unit strain.

A *Stress-Strain Diagram* is a diagram plotted with values of applied load, stress, or unit stress as ordinates; and values of strain, or unit strain as abscissas.

Fig. 1 is an example of a stress-strain diagram.

Stress-strain diagrams are in some cases drawn directly by an autographic attachment to the testing machine. A more usual method of procedure consists in taking a series of load readings (from the balanced scale beam of the testing machine) with corresponding readings of the strain-indicating apparatus (extensometer, compressometer, deflectometer, or torsion indicator). The term "extensometer reading" will be used to denote the reading of any strain-measuring instrument. From these readings, or from values computed from them, there is plotted a diagram with stress-indicating values (load, flexural moment, twisting moment, or unit stress) as ordinates, and strain-indicating values (elongation, shortening, deflection, twist, or unit strain) as abscissas. In planning such a test it is necessary to decide on the increment of load or the increment of reading of extensometer to be used between successive readings.

In Fig. 2 are shown three typical stress-strain diagrams. The material for all three tests is the same, and the test specimens are all the same size, so that the diagrams should be the same. The diagram shown in Fig. 2 (*a*) is plotted from points determined by taking increments of load (S). In this diagram it is seen that owing to the shape of the curve, data for locating points between M and N are lacking. That particular portion of the curve (the "knee" of the curve) is the part for which it is especially desirable to locate several points on the diagram.

In Fig. 2 (*b*) is shown a diagram plotted from points determined by taking increments of extensometer reading (e). It will be noted that for this diagram there are located several points near the knee of the curve, and the shape of the diagram in this important region is much more definitely determined than for the curve shown in Fig. 2 (*a*).

The custom of choosing increments of load rather than increments of extensometer reading is quite common in tests of materials and is followed because, in general, it is easier to compute increments of load than it is to compute increments of extensometer reading. An estimate of the load necessary to stress the specimen up to the knee of the curve is made and some fraction (frequently one-tenth) of this value is taken as an increment. The computation of the corresponding increment of extensometer reading is more complicated.

Sometimes the practice is followed of applying a few increments of load as determined above, and then applying load in much smaller increments (S') until the knee of the curve is passed. Fig. 2 (*c*) shows a diagram obtained in this manner. This method involves a marked increase in the number of readings necessary for a test and with unknown material there is always some danger that the knee of the curve will be reached before the use of small increments of load is begun.

The following method of choosing increments for a test is suggested: Estimate the load corresponding to the knee of the stress-strain diagram and choose a value for increment of load about one-tenth of this value. Apply this increment of load (S) once and note the corresponding change of reading for the extensometer (e). Then for the remainder of the test, use for the increment of extensometer reading a value which corresponds to some convenient interval on the scale of the extensometer, and which is approximately equal to (e).

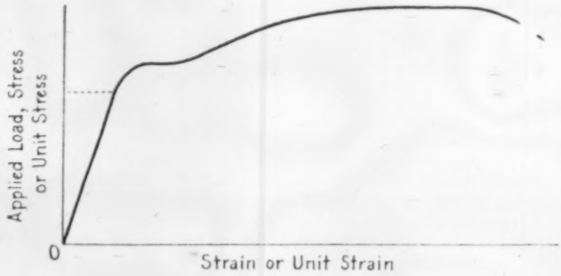
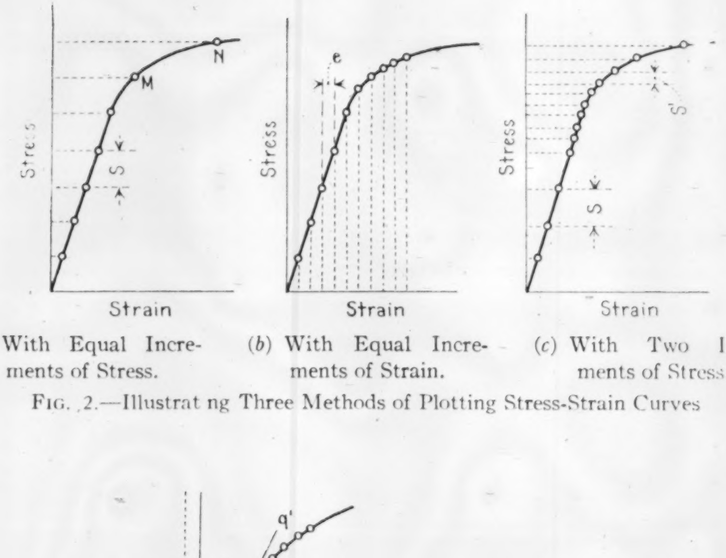


FIG. 1.—A Typical Stress-Strain Diagram.


Stress
N
M
S
Strain
Stress
e
Strain
Stress
S'
S
Strain

(*a*) With Equal Increments of Stress.

(*b*) With Equal Increments of Strain.

(*c*) With Two Increments of Stress.

FIG. 2.—Illustrating Three Methods of Plotting Stress-Strain Curves

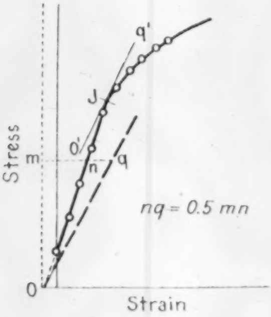

q'
J
0'
m
n
q
Stress
nq = 0.5 mn
0
Strain

FIG. 3.—Illustrating Method II for Determining Elastic Limit.

Elastic Limit. The elastic limit of a material is the greatest unit stress which it can withstand without deformation which remains upon release of the load.

Since experience does not indicate any appreciable difference between the elastic limit and the limit of proportionality of stress to strain (sometimes called the proportional limit), the determination of the unit stress at the limit of proportionality of stress to strain is regarded as an accurate determination of the elastic limit.

It is obvious that the values obtained in tests for determining the elastic limit will depend on the delicacy of methods and instruments used. It becomes necessary, therefore, that in any test the method used in obtaining the elastic limit be clearly stated. The following methods are in common use for determining a value designated as the elastic limit:

I. (For tension tests only). The elastic limit shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.

II. This method (proposed by the late J. B. Johnson) is a somewhat more delicate method for locating the elastic limit than is Method I. In Method II, the elastic limit shall be taken as that unit stress at which the rate of deformation is 50 per cent greater than the initial rate of deformation. A stress-strain diagram is necessary for determining the elastic limit by Method II. Fig. 3 illustrates the use of Method II. The initial rate of deformation is given by the ratio $mn : Om$. $nq = 0.5\ mn$, $mq = 1.5\ mn$, and the slope of Oq represents a rate of deformation 50 per cent greater than the initial rate. $O'q'$ is drawn parallel to Oq and tangent to the stress-strain diagram. The point of tangency J locates the elastic limit. In using Method II the same precautions should be observed in attaching the extensometer as for the determination of the elastic limit by Method I. Method II, if used for tension tests of metals, gives lower values for the elastic limit than does Method I. It is recommended that in using Method II for tension tests the extensometer be of such sensitiveness that it will indicate a change of unit strain of 0.0001 in. per inch of gage length (0.0001 mm. per millimeter of gage length) and that a corresponding degree of sensitiveness be required for strain meters used for compression tests, for flexure tests, and for torsion tests.

When it is desired to determine the elastic limit with a high degree of precision it is suggested that the experimenter devise his own procedure, and in reporting his results describe the procedure in detail, including a statement of the limits of sensitiveness of the apparatus used, and of the procedure used in plotting the stress-strain diagram from which the determination of elastic limit is made. It is to be remembered that the accurate determination of the elastic limit requires the use of accurate and sensitive instruments, and the use of accurate methods of plotting test data.

Yield Point is the unit stress at which there occurs a marked increase in strain without an increase in stress.

Some metals do not show a clearly defined yield point.

Two methods are in use for determining the yield point: (I) The "drop of the beam" method, and (II) the method by use of dividers. In Method I, load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at a steady rate. At the yield point the increase of load stops, but the operator, running out the poise at a steady rate, runs it a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device there is a sudden halt of the load-indicating pointer, corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding unit stress is taken as the yield point. This method of determining the yield point requires only one man to conduct a test.

In Method II for determining the yield point one observer keeps the beam of the testing machine balanced, and another observer with a pair of dividers watches for visible elongation between two gage marks on the specimen. When visible stretch is observed the fact is at once reported to the man operating the beam of the testing machine, the load at that instant is noted, and the unit stress corresponding to the load is taken as the yield point. When an extensometer[1] is used in place of dividers a deformation of 0.01 in. over a gage length of 2 in. shall be regarded as indicating the yield point.

Tensile Strength or *Ultimate Tensile Strength* is the maximum unit stress carried by a test specimen in a tension test to rupture.

Modulus of Elasticity of any material is the ratio, within the elastic limit, of unit stress to corresponding unit strain.

As there are three kinds of stress, so there are three moduli of elasticity for any material: the modulus in tension, the modulus in compression, and the modulus in shear. The value of the modulus of elasticity in tension is nearly the same, for most metals, as the value of the modulus of elasticity in compression. The value of the modulus of elasticity in shear is smaller than the value of the modulus of elasticity in tension. The modulus of elasticity is expressed in pounds per square inch (kilograms per square millimeter).

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[1] The determination of yield point with an extensometer is sometimes made in tests of non-ferrous metals.

SUGGESTED METHODS FOR VERFICATION OF TESTING MACHINES.

A REPORT OF PROGRESS IN THE REVISION OF THE STANDARD METHODS OF MECHANICAL TESTING OF METALLIC MATERIALS (E 1 – 18).

I. DEFINITIONS.

1. (*a*) *Testing Machine.*—A mechanical device for applying a load (force) to a specimen of material. **Definitions.**

Usually the magnitude of the load can be changed at the will of the operator. Many testing machines are arranged to measure the load, but this is not always the case, especially with impact machines and machines for testing ductility.

(*b*) *Error.*—In the case of a testing machine, the value obtained by subtracting the correct value of the quantity measured (usually load) from the indicated value as given by the testing machine.

(*c*) *Percentage of Error.*—In the case of a testing machine, the figure obtained by dividing the error by the correct value of the quantity measured and multiplying by 100.

(*d*) *Correction.*—In the case of a testing machine, the value obtained by subtracting the indicated value of the quantity measured from the correct value of the quantity measured.

The correction is the amount to be added (with due regard for sign) to the indicated value to give the correct value of the quantity measured. It may be noted that the "error" and the "correction" for a testing machine have equal numerical values, but opposite signs.

It is recommended that, except for very special cases, no corrections be used on machines tested and found to have errors within the tolerances given in these standards.

(*e*) *Tolerance.*—In the case of a testing machine, the maximum allowable error of the indicated value of the quantity indicated by the testing machine.

It is convenient to express tolerance in terms of percentage of error. The numerical value of the tolerance for a testing machine is so stated hereafter in these standards.

(*f*) *Accuracy.*—A testing machine is accurate if the indicated load is within the specified tolerance of the actual load.

The word "accurate" applied to a testing machine shall be used without numerical values. The word "error" shall be used with numerical values. For example: "An accurate testing machine was used for the investigation"; but "The error of the testing machine at a load of 30,000 lb. was 15 lb."

The *accuracy* of a testing machine should not be confused with *sensitiveness*. For example, a testing machine might be very sensitive—that is, it might indicate quickly and definitely small changes in the load—but, nevertheless, be very inaccurate. On the other hand, the accuracy of the results is, in general, limited by the sensitiveness.

(*g*) *Loading Range.*—In the case of a testing machine, the range of indicated loads for which the testing machine gives results within the specified tolerances. The loading range shall not include loads either greater than the largest load or less than the smallest load applied in verifying the testing machine.

II. METHODS FOR VERIFYING TESTING MACHINES THAT MEASURE LOAD.

Direct Methods Recommended.

2. Wherever practicable, testing machines shall be verified by direct methods, that is, by applying standard weights directly to the weighing mechanism of the testing machine, or by the use of standardized proving levers in connection with standard weights. The test loads selected shall be applied in both ascending and descending order, and the indications for both the ascending series and the descending series of loads shall be considered in the application of tolerances.

For machines in which the load-indicating device is actuated by a Bourdon pressure tube, a hydraulic (or steam-engine) indicator spring, or other device depending on the elastic properties of a material, the tolerances for the *descending* load shall be applied to differences in the indication for the corresponding ascending and descending readings. In such testing machines the test for ascending load shall be applied as rapidly as practicable after the testing machine has remained unloaded for at least six hours, and the time of applying the ascending series of loads shall not exceed thirty minutes. The descending load test shall be made after the maximum test load has remained on the machine for one hour, and the readings for descending loads shall be taken as rapidly as possible, and in any event the descending load test shall be completed within a period of twenty minutes.

Selection of Test Loads.

3. For any loading range the testing machine shall be verified by at least four test loads. It is recommended that the test loads used be 10, 20, 50, and 100 per cent of the maximum capacity at which the testing machine is to be used.

Where a large amount of testing of small specimens is to be done on a large-capacity machine, it is recommended that the verification outlined above be supplemented by a series of smaller test loads selected in reference to the light work to be done on the testing machine.

(*A*) *Method of Verification by Standard Weights.*

Method by Standard Weights.

4. Standard metal weights of suitable design, finish, and adjustment shall be placed on the weighing platform of the testing machine or upon trays or other supports suspended from the load-measuring

mechanism in place of the specimen. The weights shall be applied in increments and removed in the reverse order. They shall be arranged symmetrically with respect to the weighing platform, so that the center of gravity of the load lies in the vertical line through the center of the platform. It is recommended that the total load of weights for any test load be applied in four equal increments. The applied load and the indicated load shall be recorded for each increment of test load applied, and the error computed from these data.

The method of verification by standard weights can be used only on vertical testing machines. The total load is limited by the size of the platform and the number of weights available. Often twenty weights of 50 lb. each are used, a total of 1000 lb.

This method of verification is seldom used for any but small testing machines, as the loading range does not include the loads for which large machines are used.

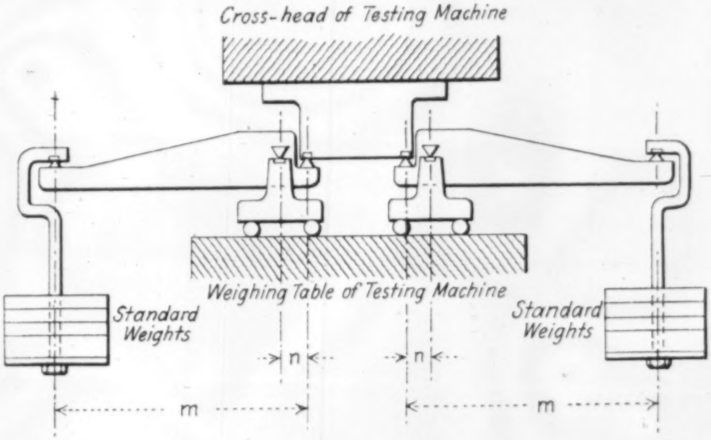
Cross-head of Testing Machine
Weighing Table of Testing Machine
Standard Weights
Standard Weights
n
n
m
m

FIG. 1.—Proving Levers.

(*B*) *Method of Verification by Standardized Proving Levers.*

Description of Levers.

5. The arrangement of proving levers for verifying testing machines is shown in Fig. 1. The two levers rest on supports on the weighing platform of the testing machine. These supports shall move easily in a horizontal direction, which insures that the forces at each of the knife edges shall be very nearly vertical. The inner knife edges in each lever bear against a suitable block in the movable head of the testing machine. Weight trays or hangers are suspended from each of the outer knife edges and these trays or hangers are loaded with standard weights. The increment of load put on the testing machine by the standard weights is the amount of standard weights multiplied by the lever ratio m/n, Fig. 1.

Specifications of Levers.

6. The knife edges, as well as their supports, shall be of hardened tool steel. The knife edges shall be ground sharp with an angle of 90 deg. The load on any knife edge shall not exceed 7000 lb. per linear inch. The three knife edges in each lever shall be parallel, and their edges shall lie in a plane. Each lever shall have machined surfaces in this or in some parallel plane, upon which a spirit level can be placed.

Verification of Levers.

7. The lever ratio of a proving lever shall be determined by the use of at least three test loads; the amount of weights used shall not be less than the maximum load applied upon one of the arms of a lever in using the levers to verify testing machines. The proving lever shall be balanced over its center knife edge with suitable weight trays suspended from the end knife edges. Standard weights shall then be applied to the trays in three steps, corresponding approximately to 50, 75, and 100 per cent of the weights available, and the proving lever shall then be brought to a balance by the use of small weights and by observations of the freely swinging proving lever. From the weights in the two weight trays the lever ratio shall be computed.

Method of Procedure.

8. The proving levers shall be placed symmetrically in the testing machine to be verified and both levers brought as near a horizontal position as is feasible, after applying each increment of load, by means of the movable head of the testing machine. The testing machine shall be balanced with the levers in place and the weight trays empty. Standard weights shall be applied in increments, half an increment in each tray, and they shall be removed in the reverse order. The weights shall be placed symmetrically on the weight trays, with the center of gravity of the weights over the center of the tray. It is recommended that the total load of weights for any test load be applied in four equal increments. The applied load and the indicated load shall be recorded for each increment of test load applied, and the error computed from these data.

The method of verification by standardized proving levers is used, at the present time, only on vertical testing machines. It is often used up to loads of 10,000 lb.

(*C*) *Verification by Comparison Method.*

Description of Comparison Method.

9. When the direct method of verification of a testing machine cannot be carried out (as is the case at present with horizontal testing machines, for example), a comparison method of verification shall be used. In this method the machine to be verified is tested by comparing its indications with the corresponding readings obtained

under the same conditions by the use of another testing machine, especially tested and verified, as specified in Section 10. The method of verification by comparison shall be carried out by the use of a series of companion specimens; half of each series are to be tested in tension in the machine to be verified, and half are to be tested in tension in the specially verified testing machine which serves as a standard machine. The general provisions respecting the application of the test loads and the loading range which are outlined in the direct method of verifying testing machines shall apply to the verification of testing machines by the comparison method, so far as is practicable.

The method of verification of a testing machine by standard weights (Section 4) and the method of verification by standardized proving levers (Sections 5 to 8) are both regarded as superior to the method of verification by the use of companion specimens. If the results of a verification test of a testing machine by the comparison method fail to agree with the results of a verification by either the standard-weight method or the proving-lever method, the results of the verification by the comparison method shall be discarded.

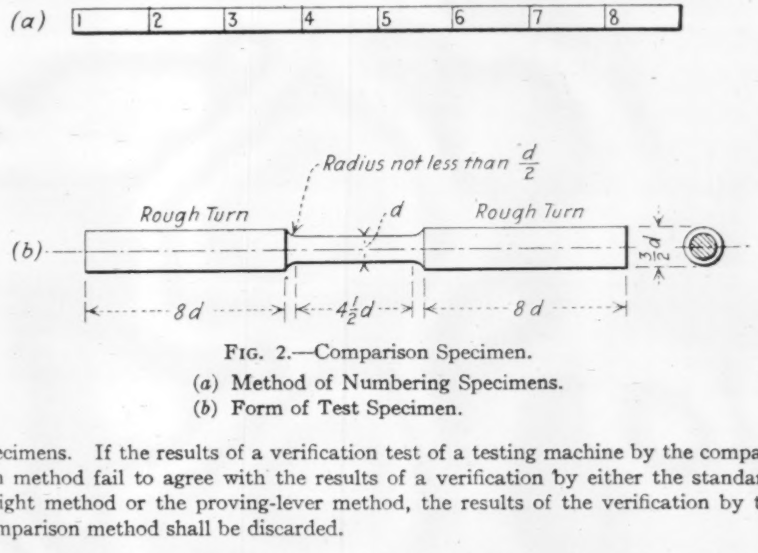

FIG. 2.—Comparison Specimen.

(a) Method of Numbering Specimens.

(b) Form of Test Specimen.

Requirements for Testing Machines used for Verifying Other Machines.

10. (a) A testing machine which is to be used as the standard for verifying other testing machines shall itself be verified by a special test, in which the verification is carried out twice. The loading range shall be determined by the tolerance for new testing machines, namely, ± 1 per cent (Section 14). For the loading range established, the differences in indications found in the two tests of the standard machine shall not exceed 0.25 per cent.

(b) In verifying testing machines by the comparison method, corrections shall be applied to the indications of the standard machine and these corrections shall be based on the average correction obtained in the two tests used in its verification.

Test Specimens.

11. (*a*) For each verification load, eight or more tension test specimens shall be cut from soft rolled or drawn steel and numbered consecutively, as in Fig. 2 (*a*).

(*b*) The tensile strength of the steel shall be determined by a preliminary test and the specimens for the comparison test shall have such cross-sectional areas as will give, approximately, the loads required. The form of the specimen shall be as shown in Fig. 2 (*b*). The ends may be threaded to fit holders, but it is recommended that those specimens shipped to another laboratory be left with cylindrical ends.

It should be noted that the A.S.T.M. standard tension test specimen, 0.5 in. diameter and 2 in. gage length, satisfies the requirements for a specimen for the verification of a testing machine by the comparison method. See 1921 Book of A.S.T.M. Standards, p. 35, Fig. 1.

Method of Procedure.

12. (*a*) The specimens having odd numbers shall be tested in the machine to be verified and those having even numbers in the standard testing machine. The tensile strength only shall be determined.

(*b*) The pulling speed of the movable head of the testing machine when testing verification specimens shall not exceed the speed of the movable head of the testing machine for determining the yield point of the material from which the specimens are made:[1] namely,

Gage Length, in.	Speed, in. per minute.
2	0.50
8	2.00

with proportional intermediate maximum speeds for gage lengths between 2 and 8 in.

(*c*) When testing verification specimens, especial care shall be taken to maintain the weighing beam of the testing machine in equilibrium as the tensile strength of the specimen is approached. It is recommended that a mark be placed at the middle of the trig loop and that a pointer be placed on the beam for verification tests, and that the pointer be kept as nearly on the mark as possible.

Computation of Error.

13. (*a*) The average strength (in pounds) of the odd-numbered specimens shall be considered the indicated load and the average strength of the even-numbered specimens shall be considered the applied load. The error shall be computed from these data.

(*b*) If the strength (in pounds) of any verification specimen varies more than 1 per cent from the mean of the group with which it is tested, its strength shall not be used in computing the error of the testing machine. If more than one specimen in the odd-numbered group or one in the even-numbered group exceeds the allowable variation in strength, all the specimens shall be discarded and another set prepared.

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[1] A speed of 0.1 in. per minute would be still better, but would make the verification process a very slow one.

III. TOLERANCES FOR TESTING MACHINES THAT MEASURE LOAD.

Tolerances.

14. All testing machines that measure load shall comply with the following tolerances:[1]

(*a*) *New Machines.*—The error for loads in the loading range shall not exceed ± 1.0 per cent of the indicated load for new machines or for those which have had any of the knife edges in the weighing mechanism repaired or renewed.

(*b*) *Used Machines.*—The error for loads in the loading range shall not exceed ± 1.5 per cent.

Corrections.

15. The indicated load of a testing machine shall not be corrected either by computation or by the use of a calibration diagram to obtain values within the required tolerance.

IV. TIME INTERVAL BETWEEN VERIFICATIONS.

Time Interval between Verifications.

16. It is recommended that testing machines, when in constant use, be verified at intervals of six months, and when used intermittently at intervals of two or three years. Testing machines shall, however, be verified immediately after making repairs or adjustments of the weighing mechanism, and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

V. REPORTS AND CERTIFICATES.

Reports.

17. A clear and complete report shall be prepared of each verification of a testing machine. This report shall contain all data necessary to verify the accuracy of the report, and shall be filed for future reference. This report shall state clearly the method of verification used.

Certificates.

18. A certificate giving the maker's serial number and a brief description of the testing machine, the maker's name, the date of verification and the loading range, shall be signed by the person responsible for the maintenance of the testing machine, and this certificate shall be posted in plain view of a person operating the testing machine.

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[1] It is believed that the tolerances given in this section may be made much smaller when more perfect methods of verification become generally available; and that the tolerances might well be materially reduced if there is available equipment for verifying testing machines by the use of standard weights (Section 4) or by the use of standardized proving levers (Sections 5 to 8).

DISCUSSION

Mr. Comstock. MR. G. F. COMSTOCK (*presented in written form*).—There is one point in this interesting report that I would discuss, and that is the determination of the elastic limit. The first method given on page 519 seems hardly worthy of mention by this Society, as results obtained in this way could not fail to be more or less inaccurate, and if such a method is to be tolerated, the determination should be known as "yield point" rather than "elastic limit". The "load at which the rate of elongation shows a sudden increase" is a quantity that could hardly be more indefinite, and would have as many different meanings as there are operators of testing machines. Figures reported from such a procedure would have no more value than ordinary yield-point determinations.

The second method is doubtless more definite, but less accurate than is necessary. If the limit of proportionality is what is desired, why not get as close to this limit as possible instead of adopting a method that is essentially in error? The real point that we want in this case is the point of tangency of the line representing the initial rate of deformation with the curved part of the diagram, or in Fig. 3, the point of tangency of the line *On*, instead of *O′q′*, with the curve. I cannot see any reason for not making the determination in this theoretically accurate way, nor any reason for the use of the lines *Oq* and *O′q′*. Even if the line *On* should be somewhat irregular, so that its slope is not absolutely uniform, the slope of *Oq* and *O′q′* depends on the exact choice of the location of the point *n*, so that this choice is necessary anyway, and having made it, why not use the line *On* as the determining tangent, and take as the locus of the elastic limit the true limit of proportionality, instead of some point like *j* which is an arbitrary distance above the real point desired?

The determination of the proportional limit by the logical and definite method that I have outlined is entirely practical, and has been used for several years in our laboratory, in numerous tests both of steels and of cast bronzes of various types. It would seem that this Society should describe and recommend only methods of unquestioned accuracy, and leave the make-shift methods like those described on page 519 to the responsibility of individual operators.

Mr. Moore. MR. H. F. MOORE.—The recognition by the Sub-Committee, of Committee E-1, on Revision of Methods E 1 – 18 of the method of determination of the elastic limit now given in many of the specifica-

Mr. Moore. tions of the Society, and of the method of determination of the elastic limit proposed by the late J. B. Johnson has been criticized, and the statement made that the standard method should be the location of the point where the stress-strain diagram first departs from a straight line. I wish to point out that the location of such a point is not a definite matter until definite specifications are given for sensitiveness of extensometer used, sensitiveness of testing machine, scales of plotting results, and increments used between readings of loads or of extensometer.

The method designated as Method I in the report has been in successful use for a number of years; it was first suggested, I believe, by Committee A-1. The method designated as Method II was proposed by the late J. B. Johnson and has been used successfully by a number of laboratories. The speaker is not willing to admit that the mere location of a point where the experimenter has decided that a stress-strain diagram departs from a straight line is by any means an "exact" location of an elastic limit. By the use of more delicate methods or by more precise plotting the "true" elastic limit may usually be found at still lower stresses, and hence it is never certain that *any* method does not merit the criticism that it determines "some point . . . which is an arbitrary distance above the real point desired".

The sub-committee has seen no other methods other than Method I and Method II which could readily be reduced to a standardized form; it therefore recommended that experimenters who wish a method more delicate than either Method I or Method II devise their own methods and state them in detail in their test reports.

The speaker feels that there is no conclusive evidence of the existance of any "absolute" elastic limit for any material in actual use, and that it is necessary to recognize that there are arbitrary factors in the determination of the elastic limit by any method.

Mr. Tour. MR. SAM TOUR.—In the Report of Committee E-1, on Methods for Verification of Testing Machines, Section II (*C*), Verification by Comparison Method, the use of eight or more specimens is called for to be cut from soft rolled or drawn steel.

It is stated that the specimens shall be of such cross-sectional area as will give approximately the loads required. In the note however, it is intimated that all of the specimens should be of the same diameter and should be the standard $\frac{1}{2}$-in. bar. The result would be a checking of the tensile machine at only one point. The general practice in using this method has been to make up eight specimens of each of two different steels of different strengths, thereby checking the machine at two points.

Mr. Tour. Referring to the various suggested methods of calibration the committee has eliminated, for the time being I presume, the method by the use of a calibration bar. This is the old method in the A.S.T.M. standards. Also, the committee does not consider the calibration box methods. There are various calibration boxes now on the market that work on the same principle as the calibration bar and, I understand, they function very satisfactorily.

In giving several methods of verification the committee should, it is believed, give their order of preference. As the report reads now one would assume that next to verification by standard weights, verification by the comparison method is preferred. In connection with verification by the comparison method the committee should carefully consider its requirements as to uniformity of strength. Assuming an average strength of say 50,000 lb. per sq. in., it would be rather difficult to get eight specimens to give results between 49,500 and 50,500 lb. per sq. in. This brings up the question as to whether or not the comparison method is sufficiently accurate for use in verification tests where the accuracy requirements are so severe.

I would also like to call attention to the fact that Section III states that the indicated load of a testing machine shall not be corrected either by computation or by the use of a calibration diagram. This seems to be a rather severe requirement and one which should bring forth considerable comment.

Attention is also called to the fact that no mention has been made of "sensitivity" of the machine.

Mr. Moore. MR. MOORE.—Mr. Tour is quite right in supposing that the calibration bar method of verifying testing machines and the calibration box method were put aside temporarily because the sub-committee was not prepared to recommend such methods in detail. In this connection a recent communication from a prominent British laboratory states that it has been their experience that there is little to choose as to accuracy between the companion bar method of verification and the calibrating bar method.

The tolerances allowed are given in terms of percentage of the indicated load on the machine. The term "loading range" has been suggested as a term found convenient in the verification of weighing scales. The use of the term "loading range" can best be illustrated by reference to an actual verification test. The following are the results of such a test recently carried out on a new 100,000-lb. machine in the laboratories of the University of Illinois:

Mr. Moore.

INDICATED LOAD, LB.	ERROR, LB.	RATIO, ERROR TO LOAD.	REMARKS.
2 000	+30	0.0150	Beyond tolerance
4 000	+30	0.0075	Within tolerance
10 000	+40	0.0040	" "
20 000	+60	0.0030	" "
40 000	+190	0.0047	" "
60 000	−200	0.0030	" "
80 000	−300	0.0037	" "
100 000	−460	0.0046	" "

The loading range of this testing machine would be from 4000 lb. to 100,000 lb.

Mr. Comstock.

MR. COMSTOCK (*by letter*).—Mr. Moore's reply to my previous discussion of this report on the subject of determination of elastic limit successfully defends the Johnson method (or Method II of the report) for determining the elastic limit, provided we assume that the stress-strain diagram has the form of a smooth curve. Actually, however, the original data obtained from the instruments are merely a series of points, between which we have no right to draw anything but straight lines. The method which I proposed for the determination is well adapted to this condition, for the elastic limit is then taken as the stress designated by the highest point of the series, above which all the points lie off the line of original slope of the diagram, by increasing distances in the same direction. In practice this works out as a definite and logical method, dependent of course for its accuracy on the accuracy of the instruments used and the care and skill applied in their operation; but the theoretical objection mentioned by Mr. Moore is unimportant practically, if the data are recognized as a series of points rather than a curve. On the other hand, the Johnson method can always be shown, when the points are plotted on a sufficiently open scale, to give results that are too high.

An illustration from our laboratory test records may make my comparison of these two methods more clear. The accompanying diagram (Fig. 1) represents a test of an annealed sample of cast steel, whose tensile properties were reported as follows:

Proportional limit	24 000 lb. per sq. in.
Yield point	34 900 " " " "
Tensile strength	64 400 " " " "
Elongation in 2 in	29.5 per cent
Reduction of area	36.8 "

The points from O to A, B, C, D, etc., were plotted from readings of a fairly delicate extensometer, attached to two opposite sides of the

Mr. Comstock.

test specimen; and these points are connected by straight lines. The straight line *ON* is also drawn to represent the average slope of the lower portion of the stress-deformation "curve", and the lines *OQ* and *O′Q′* both have a slope 1.5 times as great as that of *ON*. The elastic limit by the Johnson method would be somewhere between *B* and *C*, or from 26,000 to 28,000 lb. per sq. in., the exact point being indeterminate. By the logical method that I have used, the limit of proportionality is very clearly located at *A*, or 23,100 lb. per sq. in., but owing to the roughness of this particular test, as indicated by the distance between the determined points *A* and *B*, it seemed more reasonable to report it as 24,000 since it is known to be above 23,000, and might be even near 25,000 lb. per sq. in. It is evident, however,

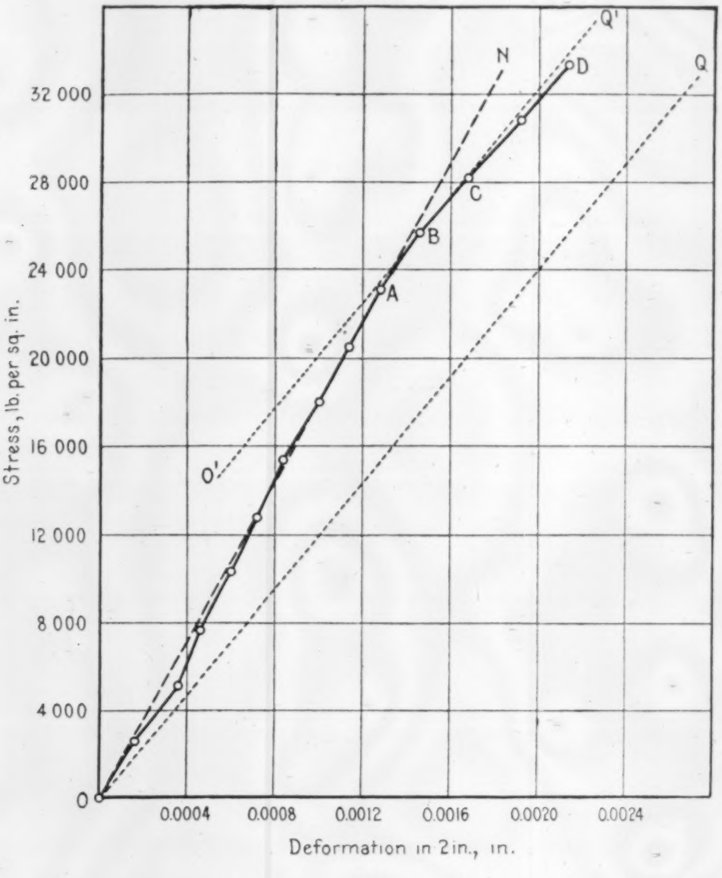

FIG. 1.—Stress-Deformation Diagram of Tension Test on Annealed Cast Steel,

Mr. Comstock.

that this point is actually below B or C, where it would be located by the Johnson method. Instances have occurred in our work where more than two points between B and D for instance fell on the line $O'O'$, and in such cases the Johnson method would be of almost no value. But some point like A can always be found, where the series of determined points departs finally from the straight line, and this surely is by definition the proportional limit.

No claim of great accuracy can be made for our work as illustrated by this diagram, and it is admitted that some of the lower points of the series are probably incorrect, and that the increment between points is too great. This is a test made under commercial laboratory conditions, with reasonable speed, and only a fairly sensitive instrument. The point I wish to emphasize is that with any given series of determined points a procedure can be followed which will give results closer to the truth than the Johnson method. Since the method which is to be called standard should give the most accurate results possible with the instruments at hand, the Johnson method should not be advocated by this Society as a standard method. It is very fitting for Committee E-1 to specify how sensitive the instruments should be for a proper determination of this kind, and how far apart the readings should be taken, and it would also be of value for it to state how great a deviation from a straight line would be permitted for points below the elastic limit without considering a test unreliable on account of irregularities in manipulation.

I trust that the above will prove of sufficient interest to be considered by Committee E-1 in revising its Suggested Definitions Relating to Methods of Testing.

Mr. Moore.

MR. MOORE (*Closure by letter*).—In connection with Mr. Comstock's proposed method for determining the elastic limit, the speaker is not at all willing to agree to the statement that "the original data obtained from the instruments are merely a series of points, between which we have no right to draw anything but straight lines." An assumption of continuity of action is certainly no less logical than the assumption of an action represented by a series of discontinuous straight lines. It will be noted that Mr. Comstock in the diagram submitted determines the limit of proportionality at 23,100 lb. per sq. in., and then states that owing to the roughness of this particular test it seemed more reasonable to report it at 24,000 lb. per sq. in. That is, Mr. Comstock has not proposed a standardized method for determining the elastic limit, but one which involves individual interpretation by the investigator. Such determinations, when found desirable, are covered by the special third method in the report of the sub-committee.

REPORT OF COMMITTEE E-5
ON
STANDING COMMITTEES.

Committee E-5 presents the following report of its activities during the past year:

The committee received from Committee E-1 on Methods of Testing a proposed addition to the Regulations Governing the Form but not the Substance of Standards[1] consisting of requirements to govern the form of methods of test as distinguished from specifications. The recommendations of Committee E-1 were based upon an extensive study of the existing methods of test of the Society, in the course of which it was seen that certain sections of the present Regulations Governing Form could hardly be applied to methods of test as they were obviously designed to apply to specifications.

Committee E-5 has carefully reviewed and approved these recommendations, and has accordingly made the following revisions in the Regulations Governing the Form but not the Substance of Standards, which are subject to annual review and revision by Committee E-5:

1. Sections 7 to 14 of the Regulations, which are now grouped under the title "Form and Sequence of Sub-Titles" have been suitably modified to apply only to specifications.
2. A new division on "Form and Sequence of Sub-Titles in Methods of Test" has been added, consisting of ten new sections especially applicable to the form and arrangement of methods of test.

As an aid to the standing committees in preparing new methods of test this year, revised copies of the Regulations Governing the Form but not the Substance of Standards were prepared and distributed to the officers of committees. The revised Regulations will appear in the current Year Book.

The letter ballot vote of the committee on the revisions of the Regulations Governing Form was as follows: 35 affirmative, none negative, 2 refrained from voting.

Committee E-1 also recommended jointly to the Executive Committee and Committee E-5 that the term "Standard Test" be eliminated from our nomenclature. There has always been some confusion and misunderstanding on the part of the standing committees as to distinction between "standard tests" and "standard methods." The recommendation of Committee E-1 was to enlarge the scope of the term "Standard Methods" so as to include methods of testing, analysis, sampling and similar operations, and to eliminate the use of the term "Standard Test." This recommendation was approved jointly by the Executive Committee and Committee E-5. Revisions that are being made in the Regulations Governing Standing Committees are being announced in the annual report of the Executive Committee.

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[1] 1920 Year Book, p. 250.

The letter ballot vote of the committee on the revisions of the Regulations Governing Standing Committees was as follows: 35 affirmative, none negative, 2 refrained from voting.

This report has been submitted to letter ballot vote of the committee which consists of 37 members, of whom 32 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-6
ON
PAPERS AND PUBLICATIONS.

Since the last annual meeting, Committee E-6 on Papers and Publications has held two meetings, December 1, 1921, and March 8, 1922. In addition to its usual function of arranging the program of the annual meeting, it has acted in an advisory capacity to the Executive Committee in several matters relating to publication policy, notably the plan of distributing preprints of reports and papers. These matters are fully covered in the annual report of the Executive Committee.

Last year the Proceedings were bound in one volume as a measure of economy, thus departing from the usual practice of binding committee reports and tentative standards in one volume and technical papers and discussions in a second. The volume thus obtained was about as large as could conveniently be bound in one cover, and in view of the greatly increased amount of printed matter for this year the committee will return to the plan of issuing the Proceedings in two volumes.

The Executive Committee has directed the Committee on Papers and Publications to proceed with the publication of an Index of the Proceedings, Vols. XIII to XX (1913–1920) and the committee will endeavor to issue this publication before the close of the year.

The committee has given a great deal of thought to the program for this annual meeting. It was decided in so far as possible to emphasize the technical papers and to arrange for discussion of important topics of timely interest. The committee has arranged what it believes is a well-balanced program, which includes discussions of such topics as Corrosion, Foundry Pig Iron, Steel Castings, Impact Testing of Materials, Fatigue of Metals, Specifications for Coal and Inspection of Concrete and Reinforced Concrete Work. Certain of the papers on these topics were solicited by the committee, notably the papers that make up the discussion on Impact Testing. An entire session has been devoted to this discussion in the form of a symposium, which has been arranged with the helpful cooperation of Committee E-1 on Methods of Testing.

A wealth of material for the meeting was available to the committee through the offer of papers by many of our members. In fact so many offers and suggestions were received that it was impossible to accept more than about one-half of them. Other offers were received too late for consideration by the committee.

The committee has felt that this situation, while clearly indicative of a very healthy condition in the Society, merits some consideration because of the increasing difficulty of providing for our ever increasing number and volume of committee reports and technical papers at the same sessions, which, together with space limitations in the Proceedings, has compelled the committee for several years past to reject some papers of value. Committee reports and papers are being presented at our annual meetings under increasing pressure as to time, frequently with little opportunity for discussion, so that the committee feels that the annual meetings are losing to some extent the interest that has characterized them in past years. Moreover, the rapidly increasing number of interests of the society are yearly adding to the difficulties. The committee therefore presented a formal resolution to the Executive Committee requesting that as an immediate solution consideration be given to the plan of holding simultaneous sessions during the annual meeting, thus giving opportunity for enlarging the program without extending the meeting beyond the period of four days, which is considered the maximum desirable; and that in the study of a more permanent solution, consideration be given to the desirability of holding annually two meetings of the Society, one as usual in June for the consideration of standards and tentative standards, and a midwinter meeting which could be a technical session for consideration of papers on testing and research. While the committee is not prepared to advocate this plan as the best solution, it merits the study that the Executive Committee is planning to give it.

In the meantime, the situation in so far as this annual meeting is concerned has been materially helped by the arrangement of simultaneous sessions on Thursday night and Friday morning, care having been taken to arrange these sessions so as to bring about as little conflict as possible.

Another change instituted this year is the adoption of a much improved form of the program, which has enabled the committee to give brief synopses of reports and papers that it is believed will add greatly to the value of the program. The policy has also been adopted of printing on each paper the title and business connection of the author.

The program contains reports from 35 of the Society's 40 standing committees. The annual report of the Executive Committee and reports from three joint committees bring the total to 39. Due to delays in the receipt of manuscripts of certain committee reports, the committee did not find it possible to distribute all reports four weeks in advance of the meeting. The distribution of reports containing recommendations as to standards was completed about ten days in advance of the meeting. The program contains 37 papers, making the total number of items 76, which is approximately twenty per cent greater than for the previous meeting.

The total number of pages preprinted this year, representing 35 of the 39 reports and 34 of the 37 papers, is 1225, compared with 848 pages for 1921. The accompanying table gives comparative data for preprints since the inauguration of the present policy in 1913:

COMPARATIVE DATA FOR PREPRINTS.

Year.	Preprints.			On Program but not Preprinted, pages.
	Distributed in Advance, pages.	Not Distributed in Advance, pages.	Total, pages.	
1913	461	238	699	81
1914	668	260	928	11
1915	891	76	967	0
1916	846	91	937	0
1917	978	100	1078	0
1918	690	180	870	19
1919	646	227	873	114
1920	647	314	961	0
1921[a][b]	581	267	848	99
1922[b]	876	349	1225	55 (est.)

[a] A printers' strike in 1921 seriously disrupted the printing schedule, making it impossible to distribute the normal proportion of papers and reports in advance.

[b] The size of type page was increased in 1921 from 4 by 6½ in. to 4½ by 7 in., increasing the amount of printed matter on a page by an average of 8 per cent.

This report has been submitted to letter ballot vote of the committee which consists of ten members, of whom 8 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-8
ON
NOMENCLATURE AND DEFINITIONS.

In its last annual report Committee E-8 on Nomenclature and Definitions reviewed briefly the history of the preparation of definitions in the Society and outlined the steps which led to the organization of the committee. It was explained that the committee had recommended to the Executive Committee that an Advisory Committee consisting of seven "members-at-large" appointed by the Executive Committee be created in order to concentrate the executive direction of the committee's work, and that the standing committees should continue to be represented on Committee E-8 by one or two "representative members." This recommendation was approved by the Executive Committee and the following "members-at-large" appointed to constitute the Advisory Committee:

Cloyd M. Chapman, *Chairman.*
G. W. Thompson, *Vice-Chairman.*
C. L. Warwick, *Ex-Officio Secretary.*

F. M. Farmer
K. G. Mackenzie
R. C. Purdy
H. P. Tiemann
L. B. Tuckerman

The Executive Committee also approved the Rules Governing Committee E-8 on Nomenclature and Definitions, prepared and adopted by the committee to govern the details of its procedure, and these, with the Regulations Governing Nomenclature and Definitions, will be printed in the current Year Book.

The Advisory Committee met for organization October 19, 1921. The regular November meeting of the main committee was cancelled and meetings of the Advisory Committee and of the main committee were held February 10, 1922. The Advisory Committee and the main committee will meet again during the present annual meeting.

As its first task, the committee has undertaken the classification and review of all tentative definitions now before the Society with the view of passing upon them before their ultimate advancement to the status of standard. The procedure to be followed in this work was carefully considered by the Advisory Committee at its October meeting, at which an Editorial Committee of three was appointed, charged with the following duties:

(*a*) To analyze, review and classify all definitions now on the records of the Society and such as may be prepared from time to time;

(*b*) To report to the Advisory Committee their recommendations regarding classification of terms:

(*c*) To consider at once all of the tentative definitions now before the Society and to make recommendations as to how these definitions shall be disposed of by Committee E-8.

The committee was given authority to communicate with the several standing committees responsible for definitions of terms, suggesting changes to be made in the form of definitions.

The members of the Editorial Committee are G. W. Thompson, H. P. Tiemann and C. L. Warwick, chairman. The committee met December 9, 1921, and proceeded at once with the consideration of tentative definitions, deferring any consideration for the present of definitions that are now standard. The committee outlined a suggested procedure for the consideration of definitions, reviewed in detail a majority of the tentative definitions, and presented a comprehensive report at the February meeting of the Advisory Committee. With certain modifications made by the Advisory Committee, the report was submitted at the February meeting of the main committee and adopted.

Committee E-8 therefore reports to the Society the following procedures that have been adopted for carrying on its work, and also reports below substantial progress in the consideration of the tentative definitions of the Society.

Procedure in Considering Definitions of Terms.—The following procedure will in general be followed in the consideration of definitions of terms:

1. All definitions of terms that are submitted by standing committees as "definitions" may be considered as being officially before Committee E-8 for consideration, inasmuch as no tentative definitions may be advanced to standard without action by Committee E-8.

2. The remaining terms, concerning which there is doubt as to the intention of the standing committees to have them construed as "definitions," should be reviewed by the Editorial Committee. If they are clearly not definitions and there is no desirability of having definitions formulated for the terms (which can be ascertained by communication with the committees concerned), they may be dropped from further consideration. Those that appear to be definitions should be referred to the standing committee responsible for them for

advice as to whether the standing committee considers them to be definitions; if so they are subject to consideration by Committee E-8.

3. If certain terms are referred to but are not clearly defined, the standing committee may be asked if it is desirable to prepare suitable definitions for these terms.

4. Definitions of terms clearly established as such in accordance with the above procedure shall be classified by the Editorial Committee with reference, for the present, simply to the interest of the Society's committees in the terms and the definitions thereof under consideration. This classification shall divide terms into:

(1) Those that apply only to one committee;
(2) Those that apply to a limited number of committees; and
(3) Those that are of general application, and hence are probably of interest to a considerable number of committees.

The Editorial Committee will make this classification:

First, With respect to the *definition* of the term as submitted to Committee E-8;
Second, With respect to the term itself (irrespective of the manner in which it is defined) and in an absolute way; and
Third, With respect to the term itself, having regard to the classification that seems desirable from the viewpoint of the Society's work in nomenclature and definitions.

Illustration.—The classification 1–3–2 designates a term the definition of which, as prepared by the standing committee, is of interest only to that committee; the term itself is of general application; but it is of such a nature that for practical purposes in the Society's work, only a limited number of the Society's committees need consider defining the term.

5. Suggestions of the Editorial Committee regarding definitions of terms shall be transmitted to the standing committee or committees concerned, and to the appropriate sub-committees of Committee E-8 appointed in accordance with Article V, Section 1, of the Rules Governing Committee E-8, which provide for the subsequent procedure.

Recommendation to Standing Committees.—Committee E-8 recommends to the standing committees that in submitting definitions each standing committee submit for the assistance of Committee E-8 the data on which each definition is based and such other existing definitions for the same term as should be considered in conjunction therewith. Each standing committee should also explain the need of such a definition being prepared and adopted by the Society. This will very much expedite the consideration of definitions by Committee E-8.

Form of Definitions.—The committee has adopted for its guidance in the editing of definitions certain forms which it recommends shall be observed by the standing committees in the preparation of definitions.

1. Omit repetition of term defined as a noun and use of verb: Thus,

"*Ash.*—Inorganic residue remaining ......"

not

"*Ash.*—(*Ash is*) inorganic residue remaining ......"

2. Where definitions are clearly intended to be of limited application, indicate that fact clearly in the definition. A definition should always be so worded that if it is quoted or otherwise used away from the immediate context, any limitations originally intended will be made evident: Thus,

"*Thickness.—In the case of hollow tile,* that dimension designed to lie at right angles to the face of the wall, floor, or other member in which it is used."

3. Use the present tense rather than the future tense in expressing properties or attributes: Thus,

"*Accelerator.*—...... any material which substantially *hastens* set."

not

"*Accelerator.*—...... any material which (*will*) substantially hasten set."

The Editorial Committee also suggests the advantage at certain times of giving synonyms and antonyms in connection with definitions: Thus,

"*Accelerator.*—......any material which substantially hastens set. *The same as......; the opposite of......*"

REPORT ON TENTATIVE DEFINITIONS.

Among the tentative standards of the Society, the committee found 133 terms for which definitions had been or seemed to have been prepared. The majority of these terms were published by the several standing committees under the title "Definitions of Terms"; other terms were defined in tentative specifications and methods; and there was a third class of terms concerning which there was some reasonable doubt as to whether the standing committees responsible for the tentative standards had really intended the particular wordings to be considered as definitions. Consultation with the appropriate standing committees established the fact that 13 of these terms were not intended to be defined. These terms are as follows, the serial designation of the tentative standards in which they appear being given in parentheses:

Committee D-2 on Petroleum Products and Lubricants:

Boiling Point (D 86)
Cloud Point (D 97)
Distillation Loss (D 86)
End Point (D 86)
Fire Point (D 92, D 93)
Flash Point (D 92, D 93)
Pour Point (D 97)
Recovery (D 86)
Residue (D 86)
Saponification Number (D 94)
Viscosity (D 88)

Committee D-4 on Road Materials:

Workability (D 62)[1]

Committee D-10 on Shipping Containers:

Boxes (D 118)

Three other terms in this class have been referred to the respective standing committees, and their status is under consideration: namely,

Fine aggregate (C 33), Coarse aggregate (C 33), Pipe laying (C 15).

The remaining terms, 117 in number, were grouped conveniently according to subject matter and the standing committees responsible for them, as follows:

	COMMITTEE PROPOSING DEFINITION.	NUMBER OF TERMS DEFINED.
Terms Relating to Coke (D 121)	D-6	15
" " " Gypsum (C 11, C 22, C 23, C 36, C 37)	C-11	16
" " " Hollow Tile (C 43)	C-10	26
" " " Metallography (E 2)	E-4	18
" " " Paint (D 16)	D-1	9
" " " Textiles (D 76, D 122, D 123)	D-13	16
" " " Timber (D 23)	D-7	10
Miscellaneous Terms:		
Creosote Oil (D 43)	D-8	1
Ductility (D 113)	D-4	1
A.S.T.M. Paraffin Wax Melting Point (D 87)	D-2	1
A.S.T.M. Lubricating Oil Precipitation Number (D 91)	D-2	1
Quicklime (C 5)	C-7	1
Hydrated Lime (C 6)	C-7	1
Specific Gravity (D 70, D 71)	D-4	1
		117

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[1] The specification in which this term appears is being withdrawn this year by Committee D-4.

Action by Committee E-8 with respect to these definitions is given below. In all cases the revisions suggested by the Editorial Committee, with such modifications as were made by the main committee, have been brought to the attention of the respective standing committees.

Terms Relating to Coke (D 121).—The 15 terms here defined by Committee D-6 on Coke are:

Coke
Beehive Coke
By-Product Coke
Gas House Coke
Domestic Coke
Foundry Coke from Beehive Ovens
Foundry Coke from By-Product Ovens
Furnace Coke from Beehive Ovens
Furnace Coke from By-Product Ovens
Coke Breeze
Dry Coke
Moisture
Ash
Volatile Matter
Fixed Carbon

The definitions of the terms "moisture" and "ash," with certain revisions suggested by the Editorial Committee, have been referred to a representative sub-committee of Committee E-8 under the chairmanship of H. C. Porter. The definitions of the remaining 13 terms are still under consideration by the Editorial Committee.

Terms Relating to Gypsum (C 11, C 22, C 23, C 36, C 37).—The 16 terms here defined by Committee C-11 on Gypsum are:

Accelerator
Aggregate
Binder
Cement
Consistency
Keene's Cement
Mortar
Plaster
Plasticity
Retarder
Stucco
Wood Fiber
Gypsum
Calcined Gypsum
Gypsum Wall Board
Gypsum Plaster Board

Consideration of the definitions of the terms "consistency" and "plasticity" is held in abeyance pending the work of a sub-committee of Committee E-1 on Methods of Testing which plans a thorough study in cooperation with Committee E-8 of the properties of materials denoted by the terms "consistency," "plasticity," "workability," etc. The committee has pointed out to Committee C-11 that the definition of "gypsum wall board" should be reconsidered and has also raised the question as to the desirability of defining "Keene's cement" if that cement is a proprietary compound. The remaining 12 definitions, with revisions (except in the case of definitions of "cement" and "mortar") suggested by the Editorial Committee have been referred to representative sub-committees for consideration. The Editorial Committee was not prepared to suggest revisions in the definitions of "cement" and "mortar," which are of wide application. The definition of "aggregate" has been referred to a sub-committee under the chairmanship of L. R. Ferguson, of which later mention is made, and the remaining 11 terms to a sub-committee, of which A. H. Apted has been designated chairman.

Terms Relating to Hollow Tile (C 43).—The 26 terms here defined by Committee C-10 on Hollow Building Tile are:

Clay Hollow Tile
Terra Cotta
Hollow Building Tile
Load-Bearing Tile
Floor Tile
Foundation Tile
Side Construction Tile
End Construction Tile
Back-up Tile
Book Tile
Hollow Tile Fireproofing
Partition Tile
Furring Tile
Porous Tile
Vitrified Tile
Salt Glazed Tile
Shale
Fire Clay
Surface Clay
Thickness
Width
Length
Shells
Webs
Cells
Scoring

The definitions of 23 of these terms were carefully reviewed by the Editorial Committee and since the terms seemed to concern only the committee that prepared them and since some questions of fact and interpretation were involved, Committee E-8 referred the definitions with certain suggested revisions to Committee C-10 for its further consideration. Committee C-10 has carefully considered these revisions; it has approved a majority of them and has proposed certain further modifications in others for the consideration of Committee E-8.

Definitions of the terms "shale," "fire clay" and "surface clay" are under consideration by a sub-committee under the chairmanship of A. S. Watts, of which later mention is made.

Terms Relating to Metallography (E 2).—The 18 terms here defined by Committee E-4 on Metallography are:

Achromatic
Alloy
Alpha Brass
Apochromatic
Etching Reagent
Equi-axed
Grain
Grain Size
Illuminator
Intercept Method for Grain Count
Lens
Achromatic Objectives
Macrograph
Magnification
Metal
Micrograph
Muntz Metal
Planimetric Method for Grain Count

These terms are still under consideration by the Editorial Committee.

Terms Relating to Paint (D 16).—The 9 terms here defined by Committee D-1 on Preservative Coatings for Structural Materials are:

Size
Varnish
Enamel
Filler
Toner
Lake
Drying Oil
Semi-Drying Oil
Non-Drying Oil

Revisions of these definitions suggested by the Editorial Committee were referred by Committee E-8 to Committee D-1, it having been established that no other committees in the Society were concerned with these definitions. Committee D-1 has formally approved the revised definitions and in its annual report at this meeting is recommending that the definitions in their proposed revised form be referred to letter ballot of the Society for adoption as standard. This recommendation has been approved by Committee E-8 by letter ballot vote as follows: Advisory Committee, affirmative, 7; negative, 0; not voting, 0; total 7; Standing Committees, affirmative, 17; negative, 0; not voting, 19; total 36.

Terms Relating to Textiles (*D 76, D 122, D 123*).—The 16 terms here defined by Committee D-13 on Textile Materials are:

Imperfections
Misweaves
Tolerances
Mechanical Fabric
Tire Builder Fabric
Tire Cord Fabric
Hose Duck
Rubber Belt Duck
Balata Belt Duck
Oil Belt Duck
Numbered Duck
Army Duck
Single Filled or Flat Duck
Enameling Duck
Crimp
Off-Square

Revisions in the wording of a majority of these definitions were suggested by the Editorial Committee. The definitions concern only Committee D-13 and the suggested revisions have therefore been referred by Committee E-8 to that committee for further consideration. Committee E-8 has requested advice from Committee D-13 regarding the need of a definition of "imperfection." The desirability of clarifying the definitions under "misweaves" has been pointed out and the suggestion has been made that the term "tolerances" be withdrawn as a definition and that the subject matter now given as a definition be included in the appropriate specification as an explanation.

The committee has also suggested the advisability of including a definition of "duck."

Terms Relating to Timber (*D 23*).—The 10 terms here defined by Committee D-7 on Timber are:

Annual Ring
Summer Wood
Dense Douglas Fir
Sound and Tight Knot
Encased Knot
Loose Knot
Rotten Knot
Ring Shake
Round Shake
Diagonal Grain

Here again these definitions concern only the committee submitting them. Revisions suggested by the Editorial Committee have been referred to Committee D-7 for consideration.

Miscellaneous Terms.—There are 7 such terms:

Creosote Oil (D 43)
Ductility (D 113)
A.S.T.M. Paraffin Wax Melting Point (D 87)
Quicklime (C 5)
Hydrated Lime (C 6)
Specific Gravity (D 70, D 71)
A.S.T.M. Lubricating Oil Precipitation Number (D 91)

The definition of "creosote oil," as submitted by Committee D-8 on Waterproofing, was not considered by Committee E-8 to be, strictly speaking, a definition. The matter was referred to Committee D-8, which has withdrawn the definition in a revision of the specification in question that is being presented by Committee D-8 at this annual meeting.

The definition of "ductility" is one submitted by Committee D-4 on Road Materials as applying to the ductility of asphalt cement and appears in Section 1 of the Tentative Method of Test for Ductility of Bituminous Materials (D 113 - 21 T). Committee E-8 has advised Committee D-4 that, as worded, this section should not be considered as a definition of "ductility" but rather a description of how that property is determined in the case of asphalt cement or semi-solid bitumen, and has requested the committee to consider some revision of this section.

Committee E-8 suggested to Committee D-2 certain minor modifications in the definition of "A.S.T.M. Paraffin Wax Melting Point." The revised definition has been adopted by that committee and incorporated in the Tentative Method of Test for Melting Point of Paraffin Wax (D 87 - 21 T) which Committee D-2 is recommending at this meeting be adopted as standard. Committee E-8 has approved the reference of this definition to standard by the following letter ballot vote: Advisory Committee, affirmative, 7; negative, 0; not voting, 0; total, 7; Standing Committees, affirmative, 19; negative, 0; not voting, 17; total, 36.

The committee also suggested certain minor modifications in the definition of "A.S.T.M. Lubricating Oil Precipitation Number," which have been adopted by that committee. This definition is not yet being advanced to standard by Committee D-2.

In the case of the definitions of "quicklime" and "hydrated lime," revisions suggested by the Editorial Committee were referred to Committee C-7 on Lime, which is the only committee concerned with these definitions. Committee C-7 has adopted the general form and arrangement but has further revised the definitions and is submitting the revised definitions to the Society at this meeting for acceptance as tentative. Committee E-8 will pass upon the revised definitions during the coming year.

The definitions of "specific gravity" appearing in the Tentative Standards D 70 and D 71 prepared by Committee D-4 on Road Materials relate to specific gravity of road oils, road tars, asphalt cements and tar pitches and have been referred to a sub-committee of Committee E-8 that is considering general definitions of specific gravity, to which reference is made below.

OTHER ACTIVITIES.

Sub-Committee on Definition of Specific Gravity.—In its last annual report the committee stated it had organized a sub-committee to consider the formulation of definitions of the terms "specific gravity," "relative specific gravity" and "apparent specific gravity," the subject having been suggested by Committee D-4 on Road Materials. This sub-committee, under the chairmanship of F. M. Farmer, has made a comprehensive study of the definitions of these terms as given in various places in the Society's Proceedings and in standard dictionaries, text books and other references, and has submitted a report of substantial progress to the main committee.

Sub-Committee on Definitions of Clay and Related Terms.—This sub-committee was organized during the past year to consider conflicting definitions of such terms as "clay," "fire clay" and "shale" that have been prepared by several committees of the Society, Committees C-3 on Brick, C-4 on Sewer Pipe, C-6 on Drain Tile, and more recently Committees C-8 on Refractories and C-10 on Hollow Building Tile. Under the chairmanship of A. S. Watts this sub-committee has made considerable progress. In its report at the February meeting, the sub-committee requested an expression of opinion as to whether definitions satisfactory in technical and legal literature were desired or simple popular definitions that would suffice to differentiate between the different types of clay. The committee expressed its opinion that the sub-committee should prepare the former type of definition. It was appreciated that it might be difficult to prepare such definitions and that it might be necessary to prepare the latter type, notwithstanding that the former is considered to be the more desirable.

Sub-Committee on Definitions of Sand and Aggregate.—In its report a year ago the committee stated that Committee C-9 on Concrete and Concrete Aggregates had requested the consideration of definitions of terms relating to concrete and concrete aggregates. Among these terms was that of "sand," which is of interest to a number of our standing committees. A sub-committee consisting of representatives of the following standing committees has been organized to prepare a definition of this term: A-3 on Cast Iron, C-1 on Cement, C-2 on Reinforced Concrete, C-3 on Brick, C-7 on Lime, C-9 on Concrete and Concrete Aggregates, C-11 on Gypsum and D-4 on Road Materials.

To this sub-committee has been referred also the definition of the term "aggregate," mentioned previously.

Sub-Committee on Definitions of Terms Relating to Concrete.—To consider other terms suggested for definition by Committee C-9, another sub-committee, consisting of representatives of Committees C-2 on Reinforced Concrete, C-9 on Concrete and Concrete Aggregates and D-4 on Road Materials, has been organized under the chairmanship of Mr. Ferguson and is considering definitions of the following terms:

Loam
Silt
Gravel
Screened Gravel
Screenings
Crusher Dust
1-in. Broken Stone
2-in. Broken Stone

Definitions of "Sieve" and "Screen."—Definitions of these terms have been prepared by Committee D-4 on Road Materials.[1] At the suggestion of Committee E-8, Committee C-9 on Concrete and Concrete Aggregates is conducting a circularization of its members to ascertain whether these definitions are satisfactory to that committee.

In conclusion, Committee E-8 feels that it has established a form of procedure that will enable it to pass upon new tentative definitions with some expedition and that the consideration of definitions now standard can be taken up as time permits. The committee expresses appreciation of the cooperation of the standing committees during the year, which cooperation is, of course, essential to the conduct of the committee's work.

This report has been submitted to letter ballot of the committee with the following result: Advisory Committee, affirmative, 7; negative, 0; not voting, 0; total, 7; Standing Committee, affirmative, 29; negative, 0; not voting, 7; total, 36.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

C. L. WARWICK,
Ex-Officio Secretary.

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[1] Definitions of Terms Relating to Materials for Roads and Pavements (D 8 - 18), 1921 Book of A.S.T.M. Standards, p. 747.

A.S.T.M.
TENTATIVE STANDARDS

SUBMITTED OR REVISED

AT THE

1922 ANNUAL MEETING.

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards its adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee whose name and address appear in the footnote to the title of each Tentative Standard.

TENTATIVE SPECIFICATIONS

FOR

LAP-WELDED AND SEAMLESS STEEL AND LAP-WELDED IRON BOILER TUBES.[1]

Serial Designation: A 83 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1921; Revised, 1922.

Note.—In the following specifications attention is called to the basis on which tubes are gaged for thickness. No variation beneath the ordered gage is allowed, all variations being on the side of thicker than ordered gage. Present standard A.S.T.M. specifications for locomotive tubes permit of variation above and below the ordered gage. The present A.S.T.M. standard specifications for stationary service, as well as Boiler Code and Marine specifications, do not permit of tubes being less than the ordered gage. Where previously used specifications permit of tubes less than the ordered gage, the purchaser in using these tentative specifications must order tubes one gage lighter than formerly to obtain the same weight and gage of tubes. For example: where 2 in. o.d. No. 11 B.w.g. cold-drawn tubes were previously ordered, 2 in. o.d. No. 12 B.w.g. should be ordered to these specifications. Tubes would be furnished which would have an average thickness of No. 11 B.w.g. They would not be less than No. 12 B.w.g. but might be No. 10 B.w.g. They would have the same nominal weight as under the previous system.

Material Covered.

1. These specifications cover lap-welded and seamless steel and lap-welded iron boiler tubes, boiler flues, superheater tubes, safe ends and arch tubes.

I. MANUFACTURE.

Process.

2. (*a*) The material for lap-welded tubes shall be made by the open-hearth process, or by the knobbled, hammered charcoal iron process.

(*b*) The material for seamless tubes shall be made by the open-hearth process.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

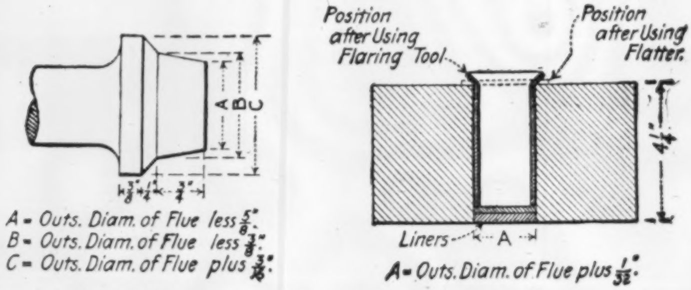
3. (*a*) Chemical analysis will not be required for charcoal iron tubes.

(*b*) Material made by the open-hearth process shall conform to the following requirements as to chemical composition:

	GRADE A.	GRADE B.
Carbon, per cent	0.08 – 0.18	not over 0.03
Manganese, "	0.30 – 0.60	" " 0.03
Phosphorus, "	not over 0.04	" " 0.02
Sulfur, "	" " 0.045	" " 0.045

Check Analyses.

4. (*a*) Analyses of two tubes in each lot of 250 tubes or less, and of 2000 feet or less of safe-end material, may be made by the purchaser. The chemical composition thus determined shall conform to the requirements specified in Section 3 (*b*). Drillings for analysis shall be taken from several points around each tube.


A
B
C
$\frac{3}{8}$"
$\frac{1}{4}$"
$\frac{3}{4}$"
A = Outs. Diam. of Flue less $\frac{5}{8}$".
B = Outs. Diam. of Flue less $\frac{3}{8}$".
C = Outs. Diam. of Flue plus $\frac{3}{16}$".
Position after Using Flaring Tool
Position after Using Flatter.
$4\frac{1}{4}$"
Liners
A
A = Outs. Diam. of Flue plus $\frac{1}{32}$".

Flaring Tool. Die Block.

FIG. 1

(*b*) If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

III. PHYSICAL PROPERTIES AND TESTS.

5. Tubes of material made by the open-hearth process shall meet the tests specified for steel tubes.

Flange Tests.

6. (*a*) For tubes not more than 6 in. in diameter and having a thickness less than 10 per cent of the outside diameter, provided the thickness does not exceed No. 6 B.w.g. (0.203 in.), a test specimen not less than 4 in. in length shall have a flange turned over at right angles to the body of the tube without cracking or showing any flaw. This flange, as measured from the outside of tube, shall in no case be less than $\frac{1}{8}$ in. nor more than $\frac{1}{2}$ in. Within these limits the width of

flange shall be not less than $12\frac{1}{2}$ per cent of the outside diameter for charcoal-iron, nor less than 15 per cent for steel tubes up to $2\frac{1}{2}$ in., inclusive. For steel tubes over $2\frac{1}{2}$ in. in diameter and up to $3\frac{3}{4}$ in., inclusive, the width of the flange shall be $\frac{3}{8}$ in., and for tubes over $3\frac{3}{4}$ in. the width of flange shall be 10 per cent of the outside diameter.

(*b*) For tubes not specified in Paragraph (*a*) the flange test will not be required.

(*c*) In making the flange test, it is recommended that the flaring tool and die block as shown in Fig. 1 be used.

Flattening Test.

7. (*a*) For all tubes, except when the wall thickness is in excess of 10 per cent of the outside diameter, providing the thickness does not exceed No. 6 B.w.g. (0.203 in.), a test specimen 3 in. in length shall withstand flattening between parallel plates, without cracking or showing any flaw, until the distance between the plates is as follows:

Three times the wall thickness for seamless tubes;
Five times the wall thickness for lap-welded tubes.

NOTE.—In the case of lap-welded tubes, the test shall be made with the weld at the point of maximum bend.

(*b*) For all tubes not specified in Paragraph (*a*) a test specimen 3 in. in length shall withstand flattening between parallel plates, without cracking or showing any flaw, until the distance between the plates is as follows:

Four times the wall thickness for seamless tubes;
Six times the wall thickness for lap-welded tubes.

NOTE.—In the case of lap-welded wrought-iron tubes thicker than No. 6 B. w. g. (0.203 in.), the test shall be made with the weld 45 deg. away from the point of maximum bend. For other wrought-iron tubes and for all steel tubes covered by this section, the test shall be made with the weld at the point of maximum bend.

Crush Tests.

8. When required by the inspector, crushing tests shall be made on test specimens $2\frac{1}{2}$ in. in length, which shall withstand crushing longitudinally, without cracking, splitting or opening at the weld, as follows:

Steel tubes: No. 10 B.w.g. or lighter to a height of $\frac{3}{4}$ in. or until outside folds are in contact; if heavier than No. 10 B.w.g. to a height of $1\frac{1}{4}$ in.

Charcoal-iron tubes: No. 10 B.w.g. or lighter, to a height of $1\frac{1}{8}$ in.; if heavier than No. 10 B.w.g., to a height of $1\frac{3}{4}$ in. Slight surface checks shall not be a cause for rejection.

Hydrostatic Tests.

9. Tubes under 5 in. in diameter shall withstand an internal hydrostatic pressure of 1000 lb. per sq. in. and tubes 5 in. or over in

TABLE I.—STANDARD WEIGHTS OF LAP-WELDED AND SEAMLESS BOILER TUBES.

INCLUDING SAFE ENDS, ARCH TUBES AND LARGE BOILER TUBES.

Thickness.		Weight, lb. per ft. of Length. Outside Diameter, in.																						
B.w.g.	In.	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4	4 1/2	5	5 1/4	5 3/8	5 1/2	6	7	8	9	10	11	12	13
13	0.095	1.679	1.932	2.186	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	0.109	1.910	2.201	2.492	2.783	3.074	3.365	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	0.120	2.089	2.409	2.729	3.050	3.370	3.691	4.011	4.331	4.652	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	0.134	2.312	2.670	3.028	3.386	3.743	4.101	4.459	4.817	5.175	5.532	6.248	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	0.148	2.532	2.927	3.322	3.717	4.112	4.508	4.903	5.298	5.693	6.088	6.879	7.669	8.064	8.262	8.459	.....	.....	.....	.....	.....	.....	.....	.....
8	0.165	.....	3.233	.....	4.114	4.555	4.995	5.436	5.877	6.317	6.758	7.639	8.520	8.960	9.181	9.401	10.282	12.044	13.807	.....	.....	.....	.....	.....
7	0.180	.....	.....	.....	4.460	4.940	5.421	5.901	6.382	6.863	7.343	8.304	9.266	9.746	9.987	10.227	11.188	13.110	15.033	16.955	.....	.....	.....	.....
6	0.203	.....	.....	.....	4.980	5.522	6.064	6.606	.....	.....	8.232	9.316	10.400	.....	.....	.....	12.568	14.736	16.904	19.072	21.240	.....	.....	.....
5	0.220	.....	.....	.....	5.357	5.944	6.531	7.119	.....	.....	.....	.....	11.231	.....	.....	.....	13.580	15.930	18.280	20.629	22.979	25.329	.....	.....
4 1/2	0.229	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.788	.....
4	0.238	.....	.....	.....	5.749	6.385	7.020	7.656	.....	.....	.....	.....	.....	.....	.....	.....	14.646	17.188	19.730	22.271	24.813	27.355	.....	32.439
3 1/2	0.2485	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31.188	.....
3	0.259	.....	4.815	5.507	6.198	6.890	7.582	8.273	8.965	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.179	26.945	29.711	.....	35.243
2 1/2	0.2715	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.008	.....
2	0.284	.....	.....	.....	6.721	.....	8.238	8.990	9.754	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29.470	32.503	.....	38.569
1 1/2	0.292	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.512	.....
1	0.300	.....	.....	.....	7.048	7.849	8.650	9.451	10.252	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34.283	.....	40.69
1/2	0.320	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	39.918	.....
0	0.340	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.971

NOTE.—Seamless tubes are at present not available above 6 in. in outside diameter.

diameter shall withstand an internal hydrostatic pressure of 800 lb. per sq. in.; provided that the fiber stress corresponding to these pressures does not exceed 16,000 lb. per sq. in. Should the fiber stress corresponding to these pressures exceed 16,000 lb. per sq. in., the test pressure shall be determined by the formula:

$$P = \frac{32{,}000\,t}{D}$$

in which P = the pressure in pounds per square inch, t = the thickness of wall in inches, and D = the inside diameter of the tube in inches. Lap-welded tubes shall be struck near both ends, while under the test pressure, with a 2-lb. steel hand hammer or the equivalent.

Etch Tests for Charcoal-Iron Tubes.

10. A cross-section of charcoal-iron tubes may be turned or ground to a true surface, polished free from dirt or cracks, and etched[1] until the soft parts are sufficiently dissolved for the iron tube to show a decided ridged surface, with the weld very distinct, while a steel tube would show a homogeneous surface.

Test Specimens.

11. Test specimens shall be taken from finished tubes. They shall be smooth on the ends and free from burrs. All specimens shall be tested cold.

Number of Tests.

12. Each tube shall be subjected to the hydrostatic test. One of each of the physical tests specified shall be made from each of two tubes in each lot of 250 or less, and each 2000 feet or less of safe end material.

Retests.

13. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 6, 7 and 8, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS.

Standard Weight.

14. The standard weights for tubes of various outside diameters and thicknesses are as indicated in Tables Nos. I and II.

Permissible Variation.

15. The weight of any tube shall not be less than that shown in Tables Nos. I and II.

V. WORKMANSHIP AND FINISH.

Workmanship.

16. (*a*) Finished tubes 4 in. or under in outside diameter shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. For tubes over 4 in.

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[1] A solution of two parts water, one part HCl (sp. gr. 1.20), and one part H_2SO_4 (sp. gr. 1.84) is recommended for the etch test.

in outside diameter, these variations shall not exceed 0.5 per cent of the outside diameter.

(*b*) Tubes shall be gaged with a Birmingham wire gage, and shall be not less than the thickness specified, except that tubes will be accepted on which the gage will go on tightly at the thinnest point.

(*c*) Cold-drawn tubes shall not, at any place, exceed the specified thickness by more than two gages.

(*d*) Hot-finished tubes shall not, at any place, exceed the specified thickness by more than three gages.

(*e*) The length shall not be less but may be $\frac{3}{16}$ in. more than that specified.

TABLE II.—STANDARD WEIGHTS OF SMALL SUPERHEATER TUBES.
SEAMLESS ONLY.

THICKNESS.		WEIGHT, LB. PER FT. OF LENGTH. Outside Diameter, in.											
B.w.g.	In.	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{5}{8}$
14	0.083	0.480	0.535	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	0.095	0.537	0.601	0.664	0.727	.....	.....	.....	.....	.....	.....	.....	.....
12	0.109	.....	.....	0.746	0.818	0.891	.....	.....	.....	.....	.....	.....	.....
11	0.120	.....	.....	.....	0.887	0.967	1.047	1.127	.....	.....	.....	.....	.....
10	0.134	.....	.....	.....	.....	1.060	1.149	1.239	1.597	1.776	1.865	1.954	2.133
9	0.148	.....	.....	.....	.....	.....	1.247	1.346	1.741	1.939	2.038	2.138	2.334
8	0.165	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.352	.....

Finish. 17. Finished tubes shall be free from injurious defects and distortion, shall have smooth ends free from burrs and shall have a workmanlike finish.

VI. MARKING.

Marking 18. The name or brand of the manufacturer, the material from which it is made, whether steel or iron, and the pressure in pounds at which it was tested, shall be legibly stenciled on each tube.

VII. INSPECTION AND REJECTION.

Inspection. 19. (*a*) Unless otherwise specified, inspection and all tests, except check analyses, shall be made at the place of manufacture. When required, the manufacturer shall furnish the purchaser of each lot of tubes a statement as to the kind of material of which the tubes are made and that the tubes have been tested and have met all the requirements of these specifications.

(*b*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications.

Rejection.

20. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 (*a*) shall be reported within five working days from the receipt of samples.

(*b*) Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Superheater tubes when properly manipulated shall stand all forging, welding, and bending operations necessary for application without developing defects. Tubes which fail in any of the above operations will be rejected, and the manufacturer shall be notified.

Rehearing.

21. Samples tested in accordance with Section 4 (*a*) which represent rejected tubes, shall be preserved for two weeks from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
CARBON-STEEL CASTINGS FOR RAILROADS.[1]

Serial Designation: A 87 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope. 1. (*a*) These specifications cover all carbon-steel castings for locomotive and car equipment, and for miscellaneous use, classified as Grade A and Grade B.

(*b*) The purposes for which the two grades are generally used are:

Grade A, unannealed, covers only such special castings as may be approved by the purchaser. *Grade A*, annealed, covers such castings not covered by Grade A, unannealed.

Grade B covers all castings for high stresses such as truck side frames, bolsters, couplers and coupler parts, locomotive frames and locomotive driving and trailer wheel centers.

Basis of Purchase. 2. Grade A castings shall be furnished annealed unless otherwise specified by the purchaser.

Grade B castings shall be furnished annealed.

I. MANUFACTURE.

Process. 3. The steel may be made by one or more of the following processes: open-hearth, electric furnace, crucible or side blow converter.

Annealing. 4. (*a*) The castings shall be allowed to become cool. They shall then be uniformly heated to the proper temperature to refine the grain, and allowed to cool uniformly.

Annealing Lugs. (*b*) For the purpose of determining the quality of annealing of all castings weighing 150 lb. or over, and of such lighter castings as shall be required by the purchaser or his representative, there shall be provided for removal by the inspector after annealing and also after reannealing, if necessary, at least one and not more than two annealing lugs. The location of the annealing lugs shall be such that when removed by the inspector they shall be indicative of the character of annealing. The standard annealing lug shall be 1 in. in height and 1 in. in width and $\frac{5}{8}$ in. in thickness where it joins the casting.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

(*c*) If, in the opinion of the inspector, a casting is not properly annealed, he may at his option require the casting to be re-annealed.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

5. The steel shall conform to the following requirements as to chemical composition:

	Grade A.	Grade B.
Manganese, per cent, not over	0.85	0.85
Phosphorus, per cent, not over	0.05	0.05
Sulfur, per cent, not over	0.05	0.05

Ladle Analyses.

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, sulfur and silicon. This analysis shall be made from drillings taken at least $\frac{1}{4}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, when requested, and shall conform to the requirements specified in Section 5.

Check Analyses.

7. An analysis may be made by the purchaser from the broken tension test specimen or from a casting representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 5. Drillings for analysis shall be taken not less than $\frac{1}{4}$ in. beneath the surface, and shall be taken in such a manner as not to impair the usefulness of a casting.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

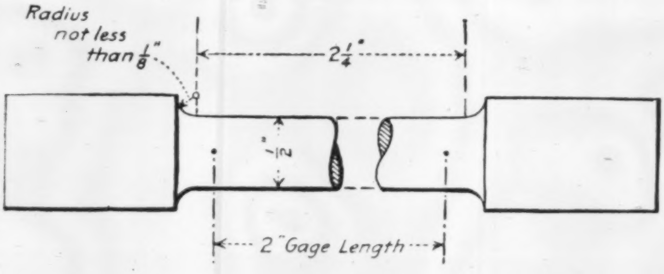
8. (*a*) The steel shall conform to the following minimum requirements as to tensile properties:

	Grade A.		Grade B.
	Unannealed.	Annealed.	Annealed.
Yield point, lb. per sq. in.	29 250	29 250	36 000
Elongation in 2 in., per cent	$\frac{1\,450\,000}{\text{Tens. str.}}$	$\frac{1\,600\,000}{\text{Tens. str.}}$	$\frac{1\,600\,000}{\text{Tens. str.}}$
but in no case less than	22	24	22
Reduction of area, per cent	$\frac{2\,250\,000}{\text{Tens. str.}}$	$\frac{2\,600\,000}{\text{Tens. str.}}$	$\frac{2\,500\,000}{\text{Tens. str.}}$
but in no case less than	30	35	30

(*b*) The tensile strength shall be reported as information.

(*c*) The yield point shall be determined by the drop of the beam or by the dividers, the method being optional with the inspector, and at a cross-head speed not to exceed $\frac{1}{8}$ in. per minute. The tensile strength shall be determined at a speed not to exceed $1\frac{1}{2}$ in. per minute.

Test Specimens. 9. (*a*) A sufficient number of test coupons, from which the required test specimen may be prepared, shall be cast attached in the neighborhood of each end of each locomotive frame, attached to each locomotive cylinder, to each wheel center, and to miscellaneous castings weighing over 150 lb. These test coupons shall remain attached to the castings throughout the annealing and until the castings are presented for inspection. If the design of the casting is such that the test coupons cannot be attached, they shall be cast in runners outside of the casting, but attached to it, to represent each melt. The location of the test coupons, as well as the method of casting such coupons, shall be subject to mutual agreement between the inspector and the manufacturer. In the case of any orders for castings weighing under 150 lb., the physical properties as required in Section 8, may be determined from an extra or spare test bar cast with and attached to some other casting from the same melt.



Note.- The Gage Length, Parallel Portions and Fillets shall be as Shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.

FIG. 1.

(*b*) When sufficient coupons have not been cast, a test specimen may be cut from a finished casting at a location mutually agreed upon by the inspector and the manufacturer.

(*c*) Tension test specimens shall conform to dimensions shown in Fig. 1. The ends shall be not less than $\frac{7}{8}$ in. in diameter and of a length and form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests. 10. (*a*) One tension test shall be made from the neighborhood of each end of each locomotive frame and both tests shall meet the requirements of the specifications. One tension test may be made from each wheel center and each locomotive cylinder casting, but of such castings at least one of each kind in each melt shall be tested. For miscellaneous castings from melts which do not include frames, wheel centers or cylinders, one tension test shall be made from each melt, except as provided in Section 11 (*a*).

(*b*) If the test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 8 and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

(*d*) No part of these specifications shall operate to cause any one tension test to apply to more than 40 tons of castings as offered for inspection.

Number of Tests, Consecutive Melts of Miscellaneous Castings.

11. (*a*) After 15 consecutive melts, which may contain any or all classes of castings (except frames, wheel centers, and cylinders) covered by these specifications on one or more orders have been tested and accepted in accordance with the above requirements, the manufacturer may group the succeeding melts in lots of five melts each, but each lot not to exceed 40 tons, the entire group to be accepted if the test specimen selected from the lot fulfills the chemical and physical requirements herein specified. If this test fails, a rehearing will be granted on the melt that the failed bar represents, and the other four melts of the group shall be tested individually.

(*b*) If there is a period of more than six months between shipments of the class of castings covered by these specifications, then each melt shall be tested individually until 15 consecutive melts have been accepted, after which the melts may again be grouped as in Paragraph (*a*).

(*c*) If one or more melts are rejected, each succeeding melt shall be tested individually until 15 consecutive melts have been accepted, after which melts may again be grouped as in Paragraph (*a*).

Number of Tests, Small Orders.

12. In case of small orders for bolsters, truck sides, draft arms, yokes or castings weighing over 150 lb. where the size of the order and the available pattern and foundry equipment are such that not more than five castings can be cast in any one melt, the physical properties, as required in Section 8, will be determined from an extra or spare test coupon cast with and attached to some other casting of the same melt.

Retests.

13. If the results of the physical test lot do not conform to the

requirements specified, the manufacturer may re-anneal such lot not more than twice and retest shall be as specified in Section 8.

Alternative Tests to Destruction.

14. In the case of orders including only castings not exceeding 150 lb. in weight, a test to destruction of one casting from each 100 castings or smaller lot may be substituted for the tension tests, at the option of the inspector. This test shall show the material to be ductile, free from injurious defects, and suitable for the purpose intended.

IV. WORKMANSHIP AND FINISH.

Workmanship.

15. The castings shall substantially conform to the sizes and shapes shown on the purchaser's drawings, and shall be made in a workmanlike manner.

Finish.

16. (*a*) The castings shall be free from injurious defects.

(*b*) Minor defects which do not impair the strength of the castings may, with the approval of the inspector, be welded by an approved process. The defects shall first be cleaned out to solid metal; and after welding, the castings shall be annealed, if required by the inspector.

V. MARKING.

Marking.

17. The manufacturer's name or indentification mark and the specified pattern number shall be cast on all castings. In addition, the month and year when made shall be cast on all bolsters, truck sides, frames, wheel centers, cylinders, and similar castings. The location and size of numbers shall be agreed upon by the manufacturer and the inspector. In accordance with the standard practice of the individual foundry to identify individual castings, a serial number may be cast or the melt number may be stamped on bolsters, truck sides, frames, wheel centers, cylinders and similar castings as agreed upon by the manufacturer and the inspector. The melt number shall be legibly stamped on all other castings weighing over 150 lb.

VI. INSPECTION AND REJECTION.

Inspection.

18. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

19. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 7 shall be reported within five working days from the receipt of samples. **Rejection.**

(*b*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

20. Samples tested in accordance with Section 7, which represent rejected castings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

TENTATIVE SPECIFICATIONS
FOR
FOUNDRY PIG IRON.[1]

Serial Designation: A 43–22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. MANUFACTURE.

Manufacture 1. The pig iron shall be clean foundry pig iron, as free as possible from an excessive amount of dross and sand, and may be either sand or machine cast.

II. CHEMICAL PROPERTIES.

Chemical Properties. 2. (*a*) The pig iron shall conform to the chemical requirements specified by the purchaser at the time of purchase, with the following permissible variations from the specified percentages:

ELEMENT.	VARIATION FROM SPECIFIED PERCENTAGE.
Silicon	0.25 per cent above and below
Sulfur	not over specified percentage
Total carbon	not less than " "
Manganese	0.20 per cent above and below
Phosphorus	0.15 " " " " "

(*b*) The percentages specified for phosphorus and manganese may be used as maximum or minimum figures, but unless so specified they shall be considered to be subject to the variations given above.

III. SAMPLING AND ANALYSIS.

Sampling. 3. (*a*) In sampling each carload, or its equivalent, shall be considered as a unit.

(*b*) One pig shall be taken to every four tons in the car, and they shall be so chosen from different parts of the car as to secure, as nearly as possible, a sample representing the average quality of the iron.

(*c*) The pigs thus taken shall be sampled by drilling so as to fairly represent the composition of the pigs as cast.

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[1] These tentative specifications, when adopted as standard, will supersede the present Standard Specifications for Foundry Pig Iron (Serial Designation : A 43-09), 1921 Book of A.S.T.M. Standards.

Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. G. C. Davies, Secretary of Committee A-3 on Cast Iron, 1410 Real Estate Trust Building, Philadelphia, Pa.

(*d*) An equal weight of the drillings from each pig shall be thoroughly mixed to make up the sample for analysis.

Analysis. 4. It is recommended that analyses be made in accordance with the Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron (Serial Designation: A 64) of the American Society for Testing Materials.[1]

IV. INSPECTION AND REJECTION.

Inspection. 5. In case of dispute, the sampling and chemical analysis shall be made in accordance with the Standard Methods of Sampling and Chemical Analysis of Pig and Cast Iron (Serial Designation : A 64) of the American Society for Testing Materials[1] by an independent chemist, mutually agreed upon, if practicable, at the time the contract is made, whose decision shall be final. The cost of such re-sampling and re-analysis shall be borne by the party in error.

Rejection. 6. All pig iron which fails to conform to these specifications shall be subject to rejection.

APPENDIX.

In using these specifications it is not advised that all five elements be specified in all contracts for pig iron, but it is recommended that, when these elements are specified, the following percentages be used, and for convenience the accompanying code is endorsed:

SILICON.

Per Cent.	Code.
1.00	La
1.50	Le
2.00	Li
2.50	Lo
3.00	Lu
3.50	Ly

(0.25 allowed either way)

SULFUR.

Per Cent.	Code.
0.04	Sa
0.05	Se
0.06	Si
0.07	So
0.08	Su
0.09	Sy
0.10	Sh

(Maximum)

TOTAL CARBON.

Per Cent.	Code.
3.00	Ca
3.20	Ce
3.40	Ci
3.60	Co
3.80	Cu

(Minimum)

MANGANESE.

Per Cent.	Code.
0.20	Ma
0.40	Me
0.60	Mi
0.80	Mo
1.00	Mu
1.25	My
1.50	Mh

(0.20 allowed either way)

PHOSPHORUS.

Per Cent.	Code.
0.20	Pa
0.40	Pe
0.60	Pi
0.80	Po
1.00	Pu
1.25	Py
1.50	Ph

(0.15 allowed either way)

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[1] 1921 Book of A.S.T.M. Standards.

Illustration of the use of above coding: The word Li-se-ca-mo-pi indicates

SILICON.	SULFUR.	CARBON.	MANGANESE.	PHOSPHORUS.
2.00	0.05	3.00	0.80	0.60

with variations as allowed.

Percentages of any element specified half way between the above shall be designated by the addition of the letter *X* to the next lower symbol.

Example.—PeX indicates Phosphorus 0.50, with allowed variations (0.15) up and down.

TENTATIVE SPECIFICATIONS
FOR
CHILLED CAST-IRON WHEELS.[1]

Serial Designation: A 46 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

I. MATERIAL.

Material. 1. Wheels shall be made of a mixture of such composition that will produce the required chill in the tread and not show any mottled iron in the plates except around the chaplets where it shall not extend more than ½ in. (12.7 mm.). (The use of steel chaplets is preferred.)

II. CHEMICAL REQUIREMENTS.

Chemical Composition. 2. (*a*) The wheels shall conform to the following requirements as to chemical composition:

	MINIMUM.	MAXIMUM.
Total Carbon, per cent	3.25	....
Combined Carbon, per cent	....	0.85
Silicon, per cent	0.45	0.75
Manganese, per cent	0.50	0.75
Phosphorus, per cent	....	0.40
Sulfur, per cent	....	0.18

(*b*) The minimum percentage of manganese shall be not less than three times the sulfur content.

Analyses. 3. Analysis shall be made by the manufacturer from test blocks poured during the day's melt from each cupola from which wheels purchased under these specifications are poured to determine the percentages of total carbon, manganese, phosphorus, sulfur and silicon.

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[1] These tentative specifications are in effect a revision of the Standard Specifications for Cast-Iron Car Wheels. The Standard Specifications, which were last published under the Serial Designation: A 46 - 05, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. G. C. Davies, Secretary of Committee A-3 on Cast Iron, 1410 Real Estate Trust Building, Philadelphia, Pa.

The chemical composition thus determined shall be reported to the purchaser or his representative upon request.

Check Analyses. 4. Drillings for check chemical analysis shall be taken from drill hole bored entirely through the back double plate of the wheel midway between the core leg holes.

III. DIMENSIONS, WEIGHT AND DESIGN OF WHEELS.

Patterns. 5. Patterns and chillers shall be such that they will produce wheels according to the dimensions shown on drawings furnished by the purchaser.

Dimensions. 6. The normal circumference conforming to the specified diameter shall be measured at a point $1\frac{23}{32}$ in. (43.65 mm.) from the gaging point on the throat of the flange. Wheels shall not vary more than $\frac{7}{16}$ in. (11.11 mm.) above or below normal size, measured on the circumference, but only $\frac{5}{16}$ in. (7.94 mm.) variation above or below normal size shall be allowed for any day's cast from one cupola.

The thickness of the flange shall be regulated by a maximum and minimum flange thickness gage which shall be not more than $\frac{1}{16}$ in. (1.59 mm.) over nor more than $\frac{1}{16}$ in. (1.59 mm.) under the normal flange.

Taping. 7. All wheels shall be taped with a standard design of wheel circumference tape and have the numbers 1, 2, 3, 4, and 5 stamped $\frac{1}{8}$ in. (3.18 mm.) apart, the figure "3" to represent normal tape size limited by $\frac{1}{16}$ in. (1.59 mm.) over or under the standard circumference, which for 33 in. (838.2 mm.) wheels will be 103.67 in. (2633.2 mm.). The figure "1" shall represent the smallest diameter, and the figure "5" the largest diameter. Tape sizes shall be stenciled in plain figures on the plate of the wheel or otherwise designated, as may be required by the purchaser.

Weights. 8. (*a*) If wheels are ordered in accordance with A.R.A. standard drawings the weights shall be as follows:

Maximum Gross Weight of Car.		Normal Weight of Wheel.		Minimum Weight of Wheel.	
lb.	kg.	lb.	kg.	lb.	kg.
95 000	43 000	650	295	640	290
132 000	59 750	700	317	690	313
169 000	76 500	750	340	740	335
210 000	95 250	850	385	835	380

(*b*) In the case of wheels ordered with cores smaller in diameter than the standard, the additional weight shall be considered as additional to the normal weight given in the above table and be paid for by the purchaser.

(*c*) In any shipment where the average weight of wheels is above the normal weight given in the above table the excess weight shall be at the expense of the manufacturer.

IV. INSPECTION.

9. Manufacturers shall notify the purchaser when ready to make shipment and shall furnish all necessary facilities and labor to enable the inspector to make test and prompt shipment of wheels. **Inspection.**

10. The body of the wheel shall be free from slag, shrinkage, or blow holes. The tread and throat shall be free from irregular wrinkles, slag, sand wash, chill cracks or sweat. Wheels will not be rejected on account of cracks around the circumference of the center core commonly known as "drawn hubs" or slight shrinkage holes on the face of the hub which will not interfere with the proper mounting of the wheels. **Surface.**

11. All wheels shall be marked and numbered consecutively in accordance with instructions issued by the purchaser. All wheels shall have the initials of the purchaser, wheel number, weight of wheel, month, day and year when made plainly cast on the inside plate of the wheel. No wheels shall have duplicate numbers and all indistinct or duplicate numbers may be corrected only after having received the approval of the inspector. All wheels shall have the name of the manufacturer and place of manufacture cast on the outside plate of the wheel. **Marking.**

12. When ready for inspection, the wheels shall be arranged in groups, all wheels of the same date being grouped together, and for each 102 wheels which pass inspection and are ready for shipment, two representative wheels shall be taken, one of which shall be subjected to the thermal test and the other shall be used for the drop test. **Sampling.**

13. (*a*) In making the thermal test the wheels shall be laid with the flange downward in the sand and a channel-way $1\frac{3}{4}$-in. (44 mm.) in width at the center of the tread for all wheels up to and including 700 lb. in weight and 2 in. (51 mm.) in width at the center of the tread for all wheels over 700 lb. in weight and 4 in. (102 mm.) deep shall be molded in green sand around the wheel, the tread of the wheel to form one side of the channel-way and the clean flange forming as much of the bottom as its width will cover. This channel-way shall be filled with molten cast iron which shall be hot enough when poured, so that the ring cast, when the metal is cold, will be solid and free from wrinkles. The time when pouring ceases shall be noted and after two minutes has elapsed an examination of the wheel shall be made. If any cracks develop in any part of the wheel, all wheels bearing the same tape size as represented by the sample shall be rejected. **Thermal Test.**

(*b*) In order to prevent spitting while pouring, the tread and flange may be covered with a coat of shellac. Wheels selected for test which are wet or which have been exposed to snow or frost may be warmed sufficiently to dry them or remove the frost before testing, but under no circumstances shall the thermal test be applied to a wheel that in any part feels warm to the hand.

Drop Test. 14. (*a*) The anvil of the drop testing machine shall be supported on rubble masonry or a concrete foundation at least 2 ft. (610 mm.) deep and shall weigh not less than 1700 lb. (770 kg.). The striking face of the tup shall be 9 in. (229 mm.) in diameter and flat. The face of each of the three bosses supporting the wheel under test shall be flat and measure 5 in. (127 mm.) in width.

(*b*) The test wheel shall be so placed on the three supports with the flange down, that the tup will strike centrally on the hub. The test wheel shall pass the requirements given in Table I without breaking in two or more pieces. If the test wheel fails, all wheels bearing the same tape size shall be rejected.

TABLE I.

Weight of Wheel. Lb.	Weight of Wheel. Kg.	Weight of Tup. Lb.	Weight of Tup. Kg.	Height of Drop. Ft.	Height of Drop. M.	Number of Blows.
650	295	250	113	9	2.75	12
700	317	250	113	$10\frac{1}{2}$	3.20	12
750	340	250	113	12	3.65	12
850	385	250	113	15	4.60	12

(*c*) If the test wheel cracks before the twelfth blow it shall be required to stand 15 blows before breaking in two or more pieces.

Chill Test. 15. The wheel selected for the drop and thermal test shall, following such test, be broken so that the chill may be examined at at least four different portions of the wheel. The depth of pure white iron shall conform to the following requirements:

Weight of Wheel.		Maximum Depth.				Minimum Depth.			
		At Middle of Tread.		At Throat.		At Middle of Tread.		At Throat.	
Lb.	Kg.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.
650	295	1	25.4	$\frac{7}{8}$	22.2	$\frac{1}{2}$	12.7	$\frac{3}{8}$	9.5
700	317	$1\frac{1}{16}$	27.	$\frac{7}{8}$	22.2	$\frac{1}{2}$	12.7	$\frac{7}{16}$	11.1
750	340	$1\frac{1}{8}$	28.6	$\frac{7}{8}$	22.2	$\frac{1}{2}$	12.7	$\frac{1}{2}$	12.7
850	385	$1\frac{1}{8}$	28.6	$\frac{7}{8}$	22.2	$\frac{1}{2}$	12.7	$\frac{1}{2}$	12.7

The depth of the chill shall not vary more than $\frac{1}{4}$ in. (6.35 mm.) in the middle of the tread on the different portions measured. If the sample does not conform to the requirements stated, all wheels of the tape size represented by the sample shall be rejected.

NOTE: The chill and physical tests specified only cover 33-in. wheels of the weights listed. Requirements for wheels of other sizes are to be supplied by the committee.

V. RETEST.

Retest.

16. Should the test wheel selected for the drop test, thermal test, or chill test fail to meet the requirements specified, all wheels bearing the same tape size shall be rejected (Sections 13, 14 and 15). The inspector shall then select another wheel of a different tape size, which shall be submitted to the same test as the wheel which failed and if it passes the requirements of the test the remainder of the lot shall be accepted, provided the requirements of all other tests have been met

VI. REJECTION.

Rejection.

17. The numbers of all wheels which have been rejected because of failure to meet the requirements of the drop test, thermal test, or chill test shall be noted and such wheels shall not be submitted for test at any future time.

Individual Rejection.

18. Individual wheels shall be rejected if:

(*a*) They are under the minimum weight specified;

(*b*) They have surface defects mentioned in Section 10;

(*c*) They are over or under the specified dimensions.

As information of possible value to the users of these specifications, Committee A-3 on Cast Iron wishes to state that the Association of Manufacturers of Chilled Car Wheels have adopted recommended designs of cast-iron car wheels of 24, 26, 28, 30, 33, 36, 39 and 42-in. diameter. The designs for the 33-in. diameter wheels have been approved by the American Railway Association. The wheels for which designs have been made, the standard for maximum load and estimated weight of the wheels are given below.

DIAMETER OF WHEEL, IN.	STANDARD FOR MAXIMUM LOAD PER WHEEL, LB.	ESTIMATED WEIGHT, LB.
24	6 000	320
24	9 000	360
24	12 000	400
24	16 000	440
26	6 000	360
26	9 000	410
26	12 000	460
26	16 000	510

Diameter of Wheel, in.	Standard for Maximum Load per Wheel, lb.	Estimated Weight, lb.
28	6 000	410
28	9 000	460
28	12 000	510
28	16 000	560
30	6 000	485
30	9 000	530
30	12 000	575
30	16 000	615
33	11 875	650
33	16 500	700
33	21 125	750
33	26 250	850
36	12 000	740
36	16 000	800
36	20 000	860
36	25 000	980
39	16 000	875
39	20 000	950
39	25 000	1 100
42	16 000	1 000
42	20 000	1 075
42	25 000	1 225

TENTATIVE SPECIFICATIONS
FOR
HIGH-TEST GRAY-IRON CASTINGS.[1]

Serial Designation: A 88 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Material Covered. 1. These specifications cover all classes of gray-iron castings which are required to have a high strength, including those generally known as semi-steel castings.

Basis of Purchase. 2. The tension test will be made only when specified by the purchaser and at his expense.

I. MANUFACTURE.

Process. 3. The castings may be made by the cupola, or any other approved process.

II. PHYSICAL PROPERTIES AND TESTS.

Transverse Tests. 4. (*a*) The transverse test specimens (arbitration test bars) specified in Section 6 (*a*), when placed horizontally upon supports 12 in. apart and tested under a centrally applied load, shall withstand a minimum load of 3800 lb. and deflect under this load at least 0.12 in. at the center.

(*b*) The rate of application of the load shall be such that a central deflection of 0.10 in. is produced in from 20 to 40 seconds.

Tension Tests. 5. When tension tests are specified, the tension test specimen shall show a minimum tensile strength of 28,000 lb. per sq. in.

Test Specimens. 6. (*a*) *Arbitration Test Bar.*—The form and dimensions of the mold for the arbitration test bar shall be in accordance with Fig. 1. The bottom of the bar shall be $\frac{1}{16}$ in. smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask shall be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried, and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply brushed off before testing.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. G. C. Davies, Secretary of Committee A-3 on Cast Iron, 1410 Real Estate Trust Building, Philadelphia, Pa.

(*b*) *Tension Test Specimen.*—When tension tests are specified, the tension test specimen shall be turned from any of the broken pieces of the transverse test specimens, and shall conform to the dimensions shown in Fig. 2.

Number of Tests.

7. (*a*) Two sets of two arbitration test bars each shall be cast from each melt, one set from the first and the other set from the last iron going into the castings. Where the melt exceeds 20 tons, an additional set of two bars shall be cast for each additional 20 tons or fraction thereof. In case of a change of mixture during the melt, one set of two bars shall also be cast for every mixture other than the regular one. Each set of two bars shall be cast in a single mold.

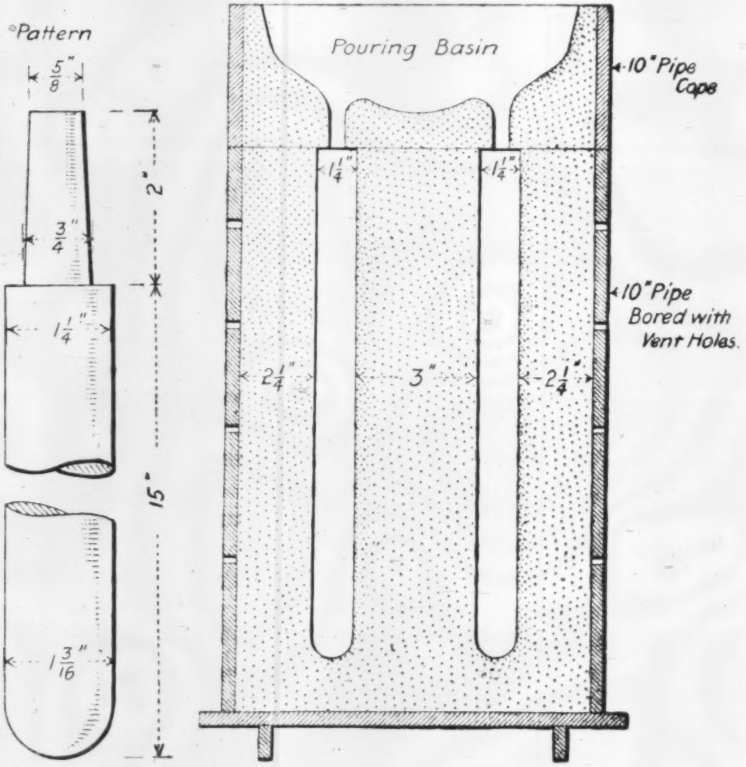

FIG. 1.—Mold for Arbitration Test Bar.

When a large casting is made for which test bars are required, the test bar shall be cast from the same ladle of iron used to pour the casting. If two ladles are used for pouring the casting, the iron for the test bars shall be poured from a ladle of iron caught between the pouring of these two ladles. In either case the test bars shall be poured at as near as possible the same temperature at which the casting is poured.

(*b*) All arbitration test bars cast shall be tested as specified in Section 4 (*a*).

Requirements.

8. One arbitration test bar of each set cast shall conform to the requirements specified in Section 4 (*a*); otherwise the castings represented by such bars shall be rejected.

III. WORKMANSHIP AND FINISH.

Finish.

9. The castings shall be true to pattern, and free from gas holes, cracks, flaws and excessive shrinkage. In other respects they shall conform to whatever points may be specially agreed upon between the manufacturer and the purchaser.

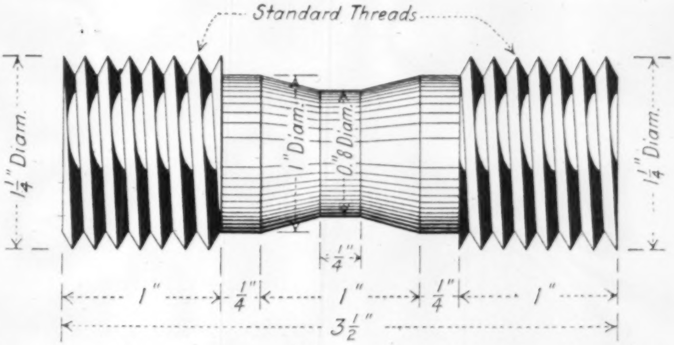

FIG. 2—Tension Test Specimen.

IV. INSPECTION.

Inspection.

10. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

TENTATIVE METHODS OF CHEMICAL ANALYSIS

OF

PLAIN CARBON STEEL.[1]

Serial Designation: A 33 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

DETERMINATION OF CARBON BY THE DIRECT-COMBUSTION METHOD.

The method of direct combustion of the metal in oxygen is recommended, the carbon dioxide obtained being absorbed in either (*a*) soda asbestos with suitable purifying and protecting trains following the furnace, or (*b*) barium hydroxide solution, the precipitated barium carbonate filtered off, washed, dissolved in a measured excess of hydrochloric acid and the excess titrated against standard alkali. Owing to the diversity of apparatus by which correct results may be obtained in the determinations of carbon, the recommendations are intended more to indicate what is acceptable than to prescribe definitely what shall be used.

APPARATUS AND REAGENTS COMMON TO BOTH METHODS.

Material for Lining Boats.—Alundum, "RR Alundum, alkali-free, specially prepared for carbon determination," as supplied by dealers is suitable, and is recommended. The 90-mesh or finer grades are used. Low-silica chrome ore, properly sized and freed from materials causing a blank, may also be employed. No substance containing alkali or alkaline earth metals, or carbon as carbonates or in other form, should be used as a lining material. Quartz sand, owing to its liability to fuse or to slag with the oxides of iron, causing bubbles of gas to be enclosed, is objectionable. Aluminum oxide, made by calcining alum or otherwise, often contains sulfate not easily destroyed, or may contain objectionable substances of an alkaline nature.

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[1] These methods, when adopted as standard, will supersede the present Standard Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 – 14), 1921 Book of A.S.T.M. Standards.

Criticisms of these Tentative Methods are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

Catalyzers.—Suitable catalyzers are asbestos, copper oxide, platinized quartz or asbestos, or platinum gauze. One of these should be used in the forward part of the combustion apparatus, as well as in the preheater preceding the combustion tube (see below). Platinized materials sometimes give off volatile substances on heating, and whatever material is used should not be subject to this defect.

Combustion Apparatus.—Any apparatus heated by electricity or gas which will bring the sample to a temperature of 950 to 1100° C. may be used. Combustion tubes may be porcelain, glazed on one or both sides, quartz or platinum. Quartz is liable to devitrification when used continuously at temperatures above 1000° C., and may then become porous.

Boats or Other Containers of Samples Being Burned.—These may be porcelain, quartz, alundum, clay, platinum, or nickel, and should always receive a lining of granular alundum or any other material found to be suitable for the purpose. Nickel boats should not be made of sheet nickel containing more than 0.3 per cent of carbon. New boats should always be preheated in oxygen before use. In order to prevent spattering and attack of the tube, a platinum or nickel cover open at both ends and allowing free access of oxygen, is desirable.

Purifying Train Before Combustion Apparatus.—This consists of a tower filled with soda-asbestos, soda-lime or granular sodium hydroxide preceded by a preheater when necessary.

Oxygen.—Oxygen of not less than 97 per cent purity is recommended. Endeavor should be made to obtain oxygen which gives no blank, since the correction for or elimination of this is troublesome and uncertain. For the most accurate work, particularly with low-carbon products, such as ingot iron, etc., the blank should be completely eliminated by the use of a preheater before the furnace, with a carbon-dioxide absorbent interposed between furnace and preheater.

FACTORS INFLUENCING RAPID COMBUSTION.

Size of Particles of Sample.—The finer the chips (short of dust, which causes low values on a hot boat) the better, except with samples which burn too vigorously (see under *Rate of Admitting Oxygen*). Particles too coarse to pass a 20-mesh sieve are not recommended, nor long curly drillings which will not pack closely. A ½-in. flat drill may be used for taking the sample and the pressure and speed of the drill-press regulated to secure the desired result; or, better still, the sample may be obtained with a small milling machine suitable for sampling, or by a shaping machine. Oil, dust, and other foreign matter should be carefully excluded.

Manner of Distributing Sample in Boat.—This is of considerable importance. With all samples, close packing in a small space is conducive to rapid combustion. In the case of samples which burn too vigorously, a satisfactory regulation may sometimes be attained by spreading the sample loosely over the lining in the boat.

Rate of Admitting Oxygen.—The rate at which oxygen is admitted is also a factor in the velocity of combustion. Assuming the combustion apparatus to be heated to the temperature range above recommended (950 to 1100° C.), it is possible, if the material is closely packed and if oxygen is admitted at too rapid a rate, that the combustion may be so violent as to cause excessive spattering of fused oxides, and such fluidity of the molten slag that the boat or other container may be injured or destroyed; therefore a moderate rate of burning is to be sought. This is desirable also to insure the complete absorption of the carbon dioxide. The factors, temperature of combustion, apparatus, manner of distribution of sample, and rate of admission of oxygen, can be governed so as to burn successfully steels of a very wide range of compositions in either fine or coarse particles.

(*a*) *Determination of Carbon* (*Carbon Dioxide Absorbed in Soda-Asbestos*).

SPECIAL APPARATUS.

Purifying and Protecting Trains.—This method requires a purifying train before and after the combustion furnace. The purifying train before the furnace may be the same as that specified under (*b*), namely, a calcium-chloride tower filled with soda-asbestos, soda-lime or granular sodium hydroxide placed before the furnace, or between the furnace and preheater, if the latter is necessary for the purpose of oxidizing organic matter in the oxygen. The purifying train after the furnace should be so designed that it will accomplish the following: (1) Remove impalpable oxide of iron which readily passes through loosely packed plugs of glass wool or asbestos or even solutions through which the oxygen is rapidly bubbled; (2) remove oxides of sulfur which are always formed; (3) dry the gases before entering the carbon-dioxide absorber; (4) dry the gases issuing from the absorber

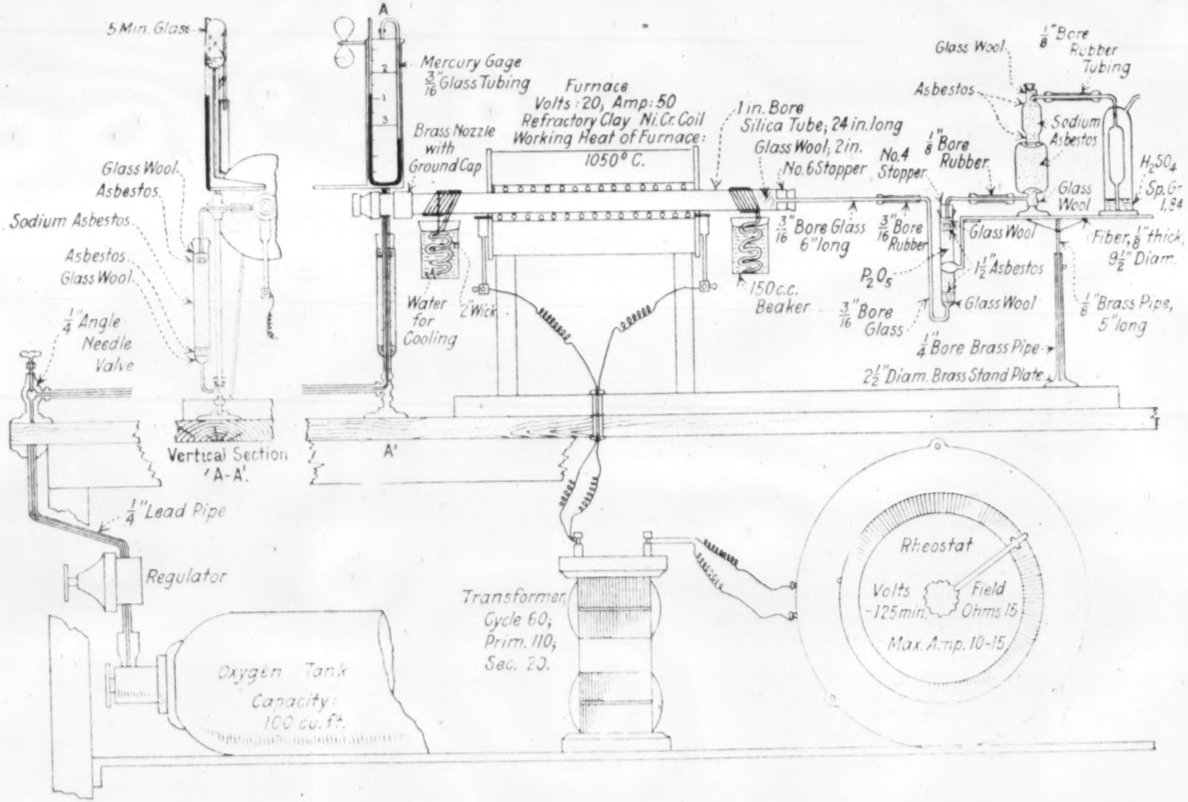
5 Min. Glass
Glass Wool
Asbestos
Sodium Asbestos
Asbestos
Glass Wool
$\frac{1}{4}$" Angle Needle Valve
Vertical Section 'A-A'.
$\frac{1}{4}$" Lead Pipe
Regulator
Oxygen Tank Capacity: 100 cu. ft.
A
Mercury Gage $\frac{3}{16}$" Glass Tubing
Brass Nozzle with Ground Cap
Water for Cooling
2" Wick
A'
Furnace Volts: 20, Amp: 50 Refractory Clay Ni.Cr. Coil Working Heat of Furnace: 1050° C.
1 in. Bore Silica Tube, 24 in. long
Glass Wool, 2 in.
No. 6 Stopper
$\frac{3}{16}$" Bore Glass 6" long
150 c.c. Beaker
No. 4 Stopper
$\frac{3}{16}$" Bore Rubber
P_2O_5
$\frac{3}{16}$" Bore Glass
$\frac{1}{8}$" Bore Rubber
Glass Wool
$1\frac{1}{2}$" Asbestos
Glass Wool
$\frac{1}{4}$" Bore Brass Pipe
$2\frac{1}{2}$" Diam. Brass Stand Plate
Glass Wool
$\frac{1}{8}$" Bore Rubber Tubing
Asbestos
Sodium Asbestos
Glass Wool
H_2SO_4 Sp. Gr. 1.84
Fiber, $\frac{1}{8}$" thick, $9\frac{1}{2}$" Diam.
$\frac{1}{8}$" Brass Pipe, 5" long
Transformer, Cycle 60, Prim. 110, Sec. 20.
Rheostat
Volts -125 min.
Field Ohms 15
Max. Amp. 10-15

FIG. 1.—Apparatus for the Determination of Carbon by the Direct-Combustion Method.

to the same extent as when they entered; and (5) protect the weighed carbon dioxide and water absorbents from outside effects

Absorbing Bulbs.—No special types are recommended although both Fleming and the Midvale (sometimes called Stetzer and Norton) bulbs have proven satisfactory. When filled, the tubes should not weigh over 200 g. and they should always be weighed filled with oxygen and against a like counterpoise. Open bulbs such as the Midvale lose oxygen by diffusion. They should be filled with oxygen before weighing when not in continuous use, and the same time interval must be held between weighings.

Absorbents.—The most desirable absorbent is soda-asbestos. The use of soda-lime is not recommended unless the reagent has been carefully tested and found to be satisfactory. Pulverized sodium hydroxide may be used.

General Arrangement of Apparatus.—Fig. 1 presents a typical arrangement in works' laboratories. For work of the highest accuracy or with very low-carbon steels the issuing gases in this train would be bubbled through concentrated sulfuric acid saturated with chromic acid before passing through the phosphorus pentoxide tube, and the upper chamber of the Fleming bulb would be filled with phosphorus pentoxide.

METHOD.

After having properly set up and tested the apparatus, moderately pack the desired weight of steel (in the form recommended above) on the bed material in the boat and introduce the boat into the combustion apparatus, which has already been heated to the proper temperature. Admit the gas after ½ to 1 minute at such a rate that the gases leave the absorbents at the rate of 200 to 400 cc. per minute. The sample burns completely in one or two minutes, and all that is now necessary is to sweep all of the carbon dioxide into the absorption bulb. Regulate the rate of flow of the oxygen between 200 and 400 cc. per minute and continue the flow for from five to ten minutes. Withdraw the absorption tube while filled with oxygen, place by the balance, and finally weigh. Remove the boat from the tube and examine the fusion for evidences of incomplete combustion.

NOTES.

1. Oxides of sulfur may cause a positive error approximating 0.005 per cent carbon in combustions of factor weights of ordinary steels when no provision is made for their removal. Sulfur trioxide can be almost entirely removed by interposing some baffle which condenses it, such as asbestos, phosphorus pentoxide, or sulfuric acid. Sulfur dioxide is not so easily removed; the most satisfactory medium

is concentrated sulfuric acid saturated with chromic acid. If not removed, sulfur dioxide may cause positive errors approximating 0.001 per cent carbon.

2. The oxides of sulfur which are fixed and accumulate in the end of the combustion tube should be periodically removed by heating the end of the tube in the hot zone of the furnace.

3. In accurate work or when dealing with low-carbon steels it is desirable to include in the weighed system a dehydrating agent which will dry the escaping gas to the same degree as when it entered the system. The loss of water from a good grade of soda-asbestos may cause losses as high as 0.01 per cent carbon in ordinary combustions. In careful work it is also desirable to protect the weighed system from moisture and carbon dioxide by means of suitable end tubes.

4. Soda-asbestos is commercially known as "Ascarite" and directions for its preparation are to be found in the *Journal Industrial and Engineering Chemistry,* Vol 8, pp. 1038–9 (1916). For the use of granular sodium hydroxide see the *Journal Industrial and Engineering Chemistry,* Vol. 13, p. 1052 (1921).

5. In some laboratories the absorbing bulbs are always kept in the balance case. In this case the balances are placed on the same table with the furnaces and each balance usually contains two absorbing bulbs which are connected by short lengths of rubber tubing to glass tubes extending out of the balance and connecting with a pair of furnaces.

6. The operator should occasionally test the apparatus and his technic by means of Bureau of Standards standard steels or steels which have been standardized in comparison with these.

(*b*) *Determination of Carbon* (*Carbon Dioxide Absorbed in Barium Hydroxide Solution*).

SPECIAL APPARATUS.

Purifying Train.—This method eliminates the necessity of a purifying train following the furnace, inasmuch as no precautions are necessary to prevent access of water vapor or oxides of sulfur from the absorbing apparatus. All that is needed is the purifying train before the combustion apparatus as mentioned above.

The Train after the Combustion Apparatus.—This consists merely of the Meyer tube for absorption of the carbon dioxide, protected by a soda-lime or soda-asbestos tube at the far end. Meyer tubes with 7 to 10 bulbs of 10 to 15-cc. capacity each, and large bulbs at the ends, having volumes equal to the combined capacity of the small bulbs, have been used and found satisfactory.

Filtering Apparatus.—In filtration for accurate work, care should be taken to protect the solution from access of extraneous carbon dioxide. This is accomplished in the apparatus shown in Fig. 2. For work requiring less accuracy, the barium carbonate may be filtered off on a filter made by fitting a carbon funnel with a perforated porcelain disk and filtering by suction. The precipitate is then washed with distilled water from which the carbon dioxide has been removed by boiling.

REAGENTS.

Tenth-normal Hydrochloric Acid.—This may be standardized by any of the accepted methods, or as follows: Measure out 20 cc. of the approximately 0.1 *N* acid (free from chlorides) with a pipette, and precipitate the silver chloride by an excess of silver-nitrate solution in a volume of 50 to 60 cc. After digesting at 70 to 80° C., until the supernatant liquid is clear, filter off the chloride on a tared Gooch filter and wash with water containing 2 cc. of HNO_3 (sp. gr. 1.42) per 100 cc. of water until free from silver nitrate. After drying to constant weight at 130° C., note the increase of weight over the original tare and from this weight, corresponding to the silver chloride, calculate the strength of the hydrochloric acid, after which adjust it to the strength prescribed. The standardization should be based upon several concordant determinations using varying amounts of acid.

$$1 \text{ cc. } 0.1\ N\ \text{HCl} = 0.0006 \text{ g. carbon.}$$

Methyl Orange.—Dissolve 0.02 g. of methyl orange in 100 cc. of hot distilled water and filter.

Tenth-normal Sodium Hydroxide Solution.—Standardize against the hydrochloric acid. Use methyl orange as the indicator. The sodium hydroxide solution should be stored in a large bottle from which it may be driven out by air pressure, protecting against carbon dioxide by soda-lime or soda-asbestos tubes.

Barium Hydroxide Solution.—Filter a saturated solution and store in a large reservoir from which it is delivered by air pressure, protecting from carbon dioxide by a soda-lime or soda-asbestos tube. In each determination fill three or four small bulbs of the Meyer tube, and add CO_2-free water until the remaining small bulbs are filled.

APPARATUS AND PROCEDURE FOR FILTRATION.

The apparatus is shown to approximately one-tenth size in Fig. 2, which is self-explanatory. The stop-cock is a three-way cock connected to the suction pipe. The rubber tubing connected to the Meyer tube should be of best-grade black rubber, and the lengths used should be so chosen as to permit of easy manipulation of the tube. The Meyer tube is connected or disconnected by the rubber stoppers which are left always attached to the rubber tubes. The carbon tube *C* is fitted with a perforated porcelain plate sliding easily.

The funnel is prepared for filtration by making on the porcelain disk a felt of asbestos about $\frac{1}{16}$ to $\frac{1}{8}$ in. in thickness, using amphibole (not serpentine) asbestos which has been carefully digested with strong hydrochloric acid for several hours and washed with water until it gives no acid reaction. On top of the asbestos pad is placed a layer of similarly treated quartz, mixed with asbestos, of the height shown. A mixture of quartz grains of various sizes (approximately 50 per cent passing a 20-mesh sieve and 50 per cent passing a 10-mesh and remaining on a 20-mesh sieve) is suitable. The mixture of quartz and asbestos may be obtained by filling the funnel from a beaker (directing against it a stream from a wash-bottle) while maintaining a gentle suction. In this way the asbestos is properly mixed with the quartz. A little experience and attention to these details will enable one to prepare the quartz-bed in a manner that will greatly expedite filtration. The stopper is now inserted in the funnel, the Meyer tube connected as shown and the liquid and precipitate sucked into the funnel. Only a gentle suction should be used. When necessary P_3 is opened to admit air back of the column of liquid in the Meyer tube. When the contents of the Meyer tube have been transferred, the large bulb nearest B is half filled with water by opening P_1; the stop-cock S is operated during this and subsequent operations so as to maintain a gentle suction all the time. M is now manipulated so as to bring the wash water in contact with all parts of the interior, after which the water is sucked through C; P_2 is left open during this and subsequent washings. After eight washings as directed, allowing

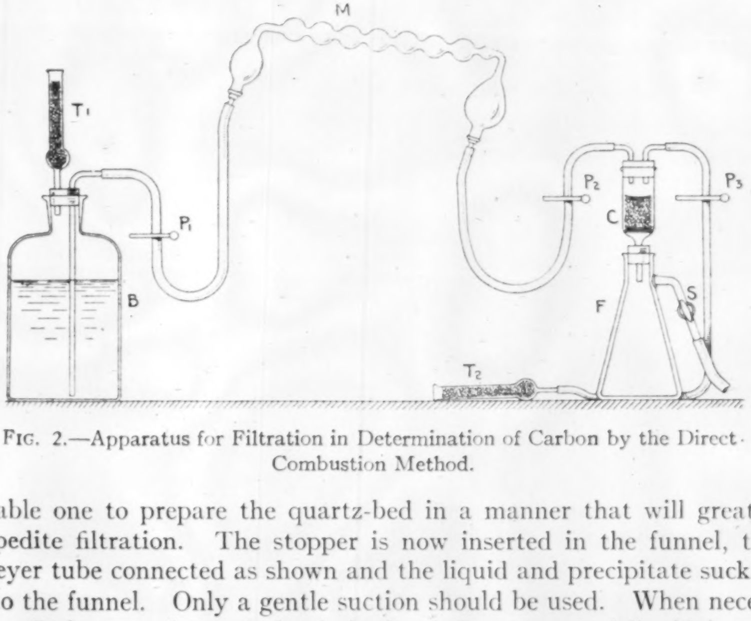

FIG. 2.—Apparatus for Filtration in Determination of Carbon by the Direct-Combustion Method.

the wash water to drain off thoroughly each time before adding more, *M* may be detached, the stopper removed from the funnel and the washings completed by filling *C* to the top with CO_2-free water, draining completely and repeating the operation once. With care the washing may be done with 150 cc. of water. Air is now admitted through the side opening of *S*, *C* is removed and the porcelain disk carrying the asbestos, quartz and barium carbonate is thrust, by means of a long glass rod, into a flask, removing any adhering particles from the sides of *C*, by a stream of water from a wash bottle. An excess of the standard acid is now added from a burette or pipette, using a portion to wash out *M*, and after the contents of the flask have been thoroughly agitated by shaking, the excess of acid is titrated against the standard alkali, using 3 drops of the methyl-orange indicator.

NOTES.

The operation of filtering can be carried out very rapidly after a little practice.

Glass wool should on no account be used as a substitute for the quartz, on account of the probability of errors arising from its attack by the alkali or acid.

It is well to wash out the rubber tubes connected to the Meyer tube with a little water each day before beginning work.

METHOD.

After having properly set up and tested the apparatus, place 2 g. of steel (Note 1) in the form recommended above, in a moderately packed condition on the bed material and introduce the boat into the combustion apparatus, already heated to the proper temperature. After $\frac{1}{2}$ to 1 minute, admit oxygen somewhat more rapidly than it is consumed, as shown by the rate of bubbling in the Meyer tube (Note 2). A rate of 200 cc. per minute is satisfactory. The sample burns completely in 1 or 2 minutes, and all that is now necessary is to sweep all the carbon dioxide into the absorption apparatus. This be accomplished in 5 to 10 minutes by passing about 1 or 2 liters of oxygen. Detach the Meyer tube (Note 2) and filter and wash the barium carbonate, using the special filtering apparatus shown. After solution in a measured excess of standard hydrochloric acid (the Meyer tube being washed out with a portion of the acid, to remove adhering barium carbonate), titrate the excess of acid against alkali and from the data thus obtained calculate the percentage of carbon.

NOTES.

1. When working with steels high in carbon (above 1 per cent) it is advisable not to use more than 1 g. in order that filtration may be sufficiently rapid.

2. As a precaution against error resulting from too rapid passage of the gases, it is well to attach a second barium-hydroxide tube to retain any carbon dioxide that may pass the first.

3. For the most accurate work the Meyer tubes should be washed with dilute acid before beginning work each day. After a determination is finished, the tube should be completely filled two or three times with tap water, then rinsed with distilled water, in order to remove the carbon dioxide liberated when dissolving the carbonate from the previous determination.

4. The flask containing the carbonate should be thoroughly agitated after adding the acid, since the carbonate sometimes dissolves rather slowly if this is not done; this is particularly the case if it has packed much during filtration.

DETERMINATION OF MANGANESE
BY THE
BISMUTHATE METHOD.

(ABSENCE OF COBALT.)

SOLUTIONS REQUIRED.

Dilute Nitric Acid (1 : 3).—Mix 500 cc. of HNO_3 (sp. gr. 1.42) and 1500 cc. of distilled water.

Dilute Nitric Acid (3 : 97).—Mix 30 cc. of HNO_3 (sp. gr. 1.42) and 970 cc. of distilled water.

Ferrous Ammonium Sulfate Solution.—Dissolve 12 g. of ferrous ammonium sulfate in a mixture of 950 cc. of distilled water and 50 cc. of H_2SO_4 (sp. gr. 1.84).

Standard Potassium Permanganate Solution.—Dissolve 1 g. of $KMnO_4$ in 1000 cc. of distilled water. Allow it to stand for at least one week and then filter through purified asbestos. Standardize against the Bureau of Standards standard sodium oxalate as follows: In a 200-cc. beaker, dissolve 0.1 g. of sodium oxalate in 75 to 100 cc. of hot water (80 to 90° C.) and add 4 cc. of H_2SO_4 (1 : 1). Titrate at once with the permanganate solution, stirring the liquid vigorously and continuously. The permanganate must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate used to cause an end point color must be estimated by matching the color in another beaker containing the same bulk of acid and hot water. The temperature of the solution should not be below 60° C. by the time the end point is reached.

Standard Sodium Arsenite Solution.—Dissolve 2 g. of sodium arsenite in distilled water, filter if necessary, and dilute to one liter. Standardize against a standard permanganate solution such as the above by titrating 10-cc. portions of the permanganate solution under the acidity and dilution conditions obtaining in the method. A clear green color free from brownish or purplish tints will be found a satisfactory and reproducible end point. The solution may also be standardized against Bureau of Standards standard plain carbon steels.

METHOD.

In a 300-cc. Erlenmeyer flask dissolve 1 g. of steel in 50 cc. of dilute HNO_3 (1 : 3), and boil to expel the oxides of nitrogen. Cool, and add about 0.5 g. of sodium bismuthate and heat for a few minutes, or until the pink color has disappeared, with or without precipitation of manganese dioxide. Add small portions of ferrous sulfate (or any suitable reducing agent) in sufficient quantity to clear the solution, and boil to expel the oxides of nitrogen. Cool to 15° C., add an excess of sodium bismuthate and agitate for a few minutes. Add 50 cc. of dilute HNO_3 (3 : 97), filter through an alundum filter or asbestos pad, and wash with the same acid. Titrate by method (*a*) or (*b*) below.

(*a*) *Ferrous Sulfate-Permanganate Titration* (less than 0.03 per cent chromium).

Add from a burette or pipette 10 to 50 cc. (depending on the amount of permanganic acid) of ferrous ammonium sulfate solution and then titrate with the standard $KMnO_4$ solution. In exactly the same manner carry through a blank determination using the same amounts of acid and bismuthate as was done with the regular sample. Finally add the exact volume of ferrous ammonium sulfate solution which was employed and titrate with the standard $KMnO_4$ solution. The difference between the volumes required in the two titrations represents the manganese in the sample.

(*b*) *Arsenite Titration* (more than 0.03 per cent chromium).

Titrate immediately with the standard sodium arsenite solution to the clear green color used as an end point in the standardization of the solution.

NOTES.

In the method, the preliminary treatment with sodium bismuthate has been found by a number of investigators to be apparently unnecessary; however, the available data to confirm this position are not considered sufficient to warrant its omission.

In making the asbestos filter pad it is advisable to have a thin bed, and as much surface as possible. This insures rapid filtration, and the filter may be used until it becomes clogged with bismuthate.

The filtrate must be perfectly clear, since the least particle of bismuthate carried through the filter will vitiate the results.

This method can not be used in the presence of cobalt.

In the arsenite titration, permanganic acid does not react in accordance with the ratio $Mn_2O_7 : 2\ MnO$, but more nearly as indicated by the ratio $Mn_2O_7 : Mn_2O_3$. Consequently the theoretical titre of the arsenite can not be used and the manganese titre must be obtained by titration of material of known manganese content under the conditions that obtain in the method.

DETERMINATION OF MANGANESE
BY THE
PERSULFATE METHOD.

(ROUTINE AND IN THE PRESENCE OF COBALT.)

SOLUTIONS REQUIRED.

Dilute Nitric Acid (sp. gr. 1.20).—Mix 380 cc. of HNO_3 (sp. gr. 1.42) and 620 cc. of distilled water.

Silver Nitrate (0.133-per-cent).—Dissolve 1.33 g. of $AgNO_3$ in 1000 cc. of distilled water.

Ammonium Persulfate Solution (10-per-cent).—Prepare as needed by dissolving 10 g. of the salt in 100 cc. of distilled water.

Sodium Chloride (0.2-per-cent).—Dissolve 2 g. of NaCl in 1000 cc. of distilled water.

Standard Sodium Arsenite.—Dissolve 0.8 g. of sodium arsenite in distilled water, filter if necessary; dilute to one liter and standardize as under "Determination of Manganese by the Bismuthate Method."

METHOD.

In a small Erlenmeyer flask or large test tube (8 by 1 in.) dissolve 0.1 to 0.3 g. of steel, depending on the manganese content of the sample, in 15 cc. of dilute HNO_3 (sp. gr. 1.20) with the aid of heat from a hot-plate or water-bath. The solution of carbon may be hastened by the addition of 1 cc. of the $(NH_4)_2S_2O_8$ solution (10-per-cent). When solution is complete and the liquid is clear, add 15 cc. of $AgNO_3$ solution (0.133-per-cent). If a tube is used, add 10 cc. of the $(NH_4)_2S_2O_8$ solution (10-per-cent) and heat in the water-bath until the color develops. If a flask is employed, bring the solution to boiling, add 10 cc. of the persulfate solution and then set aside in a warm place until the color develops. When the color has developed, cool the solution in running water, transfer to a 250-cc. beaker and dilute to a volume of 75 cc. Add 10 cc. of NaCl solution (0.2-per-cent) and titrate with the standard arsenite solution to a clear green color.

NOTES.

The persulfate oxidation requires careful attention; the solution must not be too acid and sufficient $AgNO_3$ must be present (about 15 times as much $AgNO_3$ as Mn). Consequently, in steels of high manganese content the amount of $AgNO_3$ and NaCl should be increased.

If it is desired, larger amounts of the sample can be used and correspondingly greater amounts of $AgNO_3$, NaCl and $(NH_4)_2S_2O_8$ (preferably in the form of stronger solutions).

DETERMINATION OF PHOSPHORUS
BY THE
MOLYBDATE-MAGNESIA METHOD.

SOLUTIONS REQUIRED.

Dilute Nitric Acid (sp. gr. 1.20).—Mix 380 cc. of HNO_3 (sp. gr. 1.42) and 620 cc. of distilled water.

Dilute Nitric Acid (2 : 100).—Mix 20 cc. of HNO_3 (sp. gr. 1.42) and 1000 cc. of distilled water.

Potassium Permanganate (2.5-per-cent).—Dissolve 25 g. of $KMnO_4$ in 1000 cc. of distilled water.

Dilute Ammonium Hydroxide (1 : 2).—Mix 300 cc. of NH_4OH (sp. gr. 0.90) and 600 cc. of distilled water.

Dilute Ammonium Hydroxide (1 : 19).—Mix 100 cc. of NH_4OH (sp. gr. 0.90) and 1900 cc. of distilled water.

Ammonium Bisulfite (3-per-cent).—Dissolve 30 g. of ammonium bisulfite in 1000 cc. of distilled water.

Ammonium Molybdate.—

Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of NH_4OH (sp. gr. 0.90), filter, and add 60 cc. of HNO_3 (sp. gr. 1.42).

Solution No. 2.—Mix 400 cc. of HNO_3 (sp. gr. 1.42) and 960 cc. of distilled water.

When the solutions are cold, add Solution No. 1 to Solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water, and let stand at least 24 hours before using.

Magnesia Mixture.—Dissolve 50 g. of $MgCl_2 \cdot 6H_2O$ and 125 g. of NH_4Cl in 750 cc. of distilled water, and then add 150 cc. of NH_4OH (sp. gr. 0.90).

METHOD.

In a 300-cc. Erlenmeyer flask dissolve 5 g. of steel in 75 cc. of dilute HNO_3 (sp. gr. 1.20). Heat to boiling; while boiling add about 12 cc. of the potassium permanganate solution, and continue boiling until manganese dioxide precipitates. Dissolve this precipitate by additions of ammonium bisulfite or ferrous sulfate solution, boil until clear and free from brown fumes and cool to 80° C. Add 100 cc. of the ammonium molybdate solution at room temperature, shake or agitate for 5 minutes, allow to settle, filter on a 9-cm. paper and wash the flask and precipitate at least three times with the dilute HNO_3 (2 : 100), to free from iron.

Dissolve the precipitate on the filter with dilute NH_4OH (1 : 2), letting the solution run into the original flask and avoiding the use of more than 10 to 20 cc. of the reagent. Pour a solution of 0.5 g. of citric acid in 15 cc. of water and 10 cc. of HCl (sp. gr. 1.19) through the filter in order to dissolve any ferric phosphate on the paper and render acid the ammoniacal solution of the phosphate. Transfer the solution to a 100-cc. beaker, add 10 cc. of the magnesia mixture and precipitate the phosphate by adding NH_4OH (sp. gr. 0.90) slowly and with constant stirring, until a crystallin precipitate is formed or the solution is alkaline. Finally add 10 per cent by volume excess and set aside in a cool place for 2 to 6 hours. Filter, wash with dilute NH_4OH (1 : 19), ignite and weigh. Dissolve the precipitate of magnesium pyrophosphate in 5 cc. of dilute HNO_3 (5 : 6), and 20 cc. of distilled water, filter and wash with hot water. Ignite and weigh. The difference in weights represents pure magnesium pyrophosphate containing 27.87 per cent of phosphorus.

NOTES.

The ammonium molybdate solution should be kept in a cool place and should always be absolutely clear before using.

If arsenic is present in the steel, it will come down in part with the phosphomolybdate and contaminate the pyrophosphate. In very accurate work, or when arsenic is present in appreciable amount, steps must be taken for its removal before precipitation with magnesia mixture.

DETERMINATION OF PHOSPHORUS

BY THE

ALKALIMETRIC METHOD.

(ROUTINE.)

SOLUTIONS REQUIRED.

Dilute Nitric Acid (sp. gr. 1.20).—See "Determination of Phosphorus by the Molybdate-Magnesia Method."[1]

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[1] See p. 590.

Dilute Nitric Acid (2 : 100).—See "Determination of Phosphorus by the Molybdate-Magnesia Method."[1]

Potassium Permanganate.—See "Determination of Phosphorus by the Molybdate-Magnesia Method."[1]

Ammonium Bisulfite.—See "Determination of Phosphorus by the Molybdate-Magnesia Method."[1]

Ammonium Molybdate.—See "Determination of Phosphorus by the Molybdate-Magnesia Method."[1]

Potassium Nitrate (1-per-cent).—Dissolve 10 g. of KNO_3 in 1000 cc. of distilled water.

Phenolphthalein Indicator.—Dissolve 0.2 g. of phenolphthalein in 50 cc. of 95-per-cent ethyl alcohol and 50 cc. of distilled water.

Standard Sodium Hydroxide.—Dissolve 6.5 g. of purified NaOH in 1000 cc. of distilled water, add a slight excess of 1-per-cent solution of $Ba(OH)_2$, let stand for 24 hours, decant the liquid, standardize it against a steel of known phosphorus content, as determined by the molybdate-magnesia method and dilute so that 1 cc. will be equivalent to 0.01 per cent of phosphorus on the basis of a 2-g. sample (see Notes). Protect the solution from carbon dioxide with a soda-lime or soda-asbestos tube.

Standard Nitric Acid.—Mix 10 cc. of HNO_3 (sp. gr. 1.42) and 1000 cc. of distilled water. Titrate the solution against the standard sodium hydroxide solution using phenolphthalein as indicator, and make it equivalent to the sodium hydroxide solution by adding distilled water.

METHOD.

In a 300-cc. Erlenmeyer flask dissolve 2 g. of steel in 50 cc. of dilute HNO_3 (sp. gr. 1.20). Heat the solution to boiling and while boiling add about 6 cc. of the $KMnO_4$ solution and continue boiling until manganese dioxide precipitates. Dissolve this precipitate by additions of ammonium bisulfite or ferrous sulfate solution, boil until clear and free from brown fumes, cool to 80° C., add 50 cc. of the ammonium molybdate solution at room temperature, shake or agitate for 5 minutes, allow to settle and filter on a 9-cm. paper. Wash the flask and precipitate three times with dilute HNO_3 (2 : 100) to free it from iron, and continue the washing with the 1-per-cent potassium nitrate solution until the paper, precipitate and flask are free from acid.

Transfer the paper and precipitate to the flask, add 20 cc. of distilled water, 5 drops of phenolphthalein solution as indicator, and an excess of standard sodium hydroxide solution. Insert a rubber stopper and shake vigorously until solution of the precipitate is complete. Wash off the stopper with distilled water and determine the excess of sodium hydroxide solution by titrating with standard nitric acid solution. Each cubic centimeter of standard sodium hydroxide solution represents 0.01 per cent of phosphorus.

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[1] See p. 590.

NOTES.

The ammonium molybdate solution should be kept in a cool place and should always be absolutely clear before using.

All distilled water used in titration should be freed from carbon dioxide by boiling or otherwise.

Bureau of Standards Standard Steel No. 19*a* or its renewal is recommended as a suitable steel for standardization of the sodium hydroxide solution.

The composition of phosphomolybdate varies with changes in conditions such as acidity, temperature and concentration of the molybdate reagent; consequently care should be taken to keep conditions alike in standardization and in analysis.

DETERMINATION OF SULFUR
BY THE
OXIDATION METHOD.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (2 : 98).—Mix 20 cc. of HCl (sp. gr. 1.19) and 980 cc. of distilled water.

Barium Chloride Solution (10-per-cent).—Dissolve 100 g. of $BaCl_2 \cdot 2H_2O$ in 1000 cc. of distilled water.

Barium Chloride—Hydrochloric Acid Washing Solution.—Mix 10 cc. of the above solution, 10 cc. of HCl (sp. gr. 1.19) and 1000 cc. of distilled water.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with constant stirring, into 500 cc. of distilled water.

METHOD.

Dissolve 4.57 g. of the sample in 50 cc. of HNO_3 (sp. gr. 1.42) in a covered beaker or flask. In case solution is slow or difficult, HCl (sp. gr. 1.19) may be added dropwise at intervals. When solution is complete, add 0.5 g. of Na_2CO_3, evaporate to dryness and bake for 1 hour on the hot plate. Add 30 cc. of HCl (sp. gr. 1.19) and repeat the evaporation and baking. Add another 30 cc. of HCl (sp. gr. 1.19) and evaporate to syrupy consistency. Add 5 cc. of HCl (sp. gr. 1.19) 20 cc. of water, 5 g. of 20 to 30-mesh zinc (free from sulfur), and warm on the steam-bath until the iron is reduced to the ferrous state, and the evolution of hydrogen has nearly ceased. Filter by decantation on a small filter from the silica and undissolved zinc, wash with small portions of approximately 75 cc. of dilute HCl (2 : 98), warm to 60 to 70° C. and add 10 cc. of $BaCl_2$ solution (10-per-cent). Let stand for 18 to 24 hours, filter on a paper of close texture and discard the filtrate. Wash with hot $BaCl_2$-HCl washing solution until free from iron and then with hot water until free from chlorides. Reserve the paper and precipitate and evaporate the washings to dryness. Dissolve the slight residue in 50 cc. of hot dilute HCl (2 : 98), add 1 cc. of $BaCl_2$ solution (10-per-cent), and digest at 70 to 80° C. for an hour or so, avoiding any undue evaporation. Filter on a small paper of close texture, wash with hot $BaCl_2$-HCl washing solution until free from iron and then with hot water until free from chlorides. Ignite both papers in a tared platinum crucible and treat with one drop of dilute H_2SO_4 (1 : 1) and 1 cc. of hydrofluoric acid. Evaporate to dryness, ignite and weigh. A blank should be carried through all steps of the determination and any $BaSO_4$ found deducted. The corrected weight of the ignited $BaSO_4$ multiplied by 3 represents the percentage of sulfur.

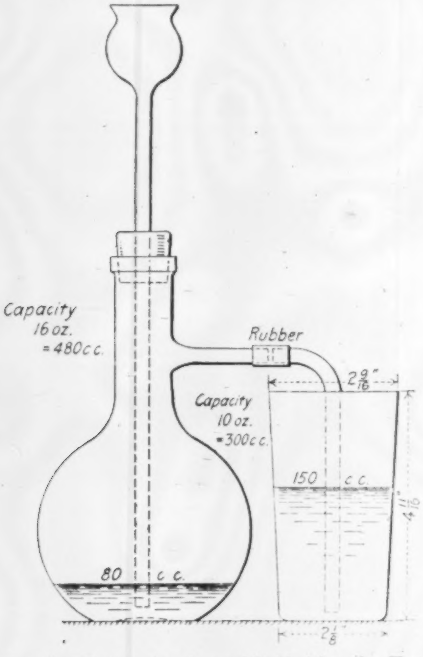

FIG. 3.—Apparatus for Determination of Sulfur by the Evolution Method.

NOTES.

The precipitation of $BaSO_4$ must not be carried out in a solution containing more than 2 cc. of HCl (sp. gr. 1.19) per 100 cc.

The recovery of $BaSO_4$ which is obtained ordinarily represents approximately 0.001 per cent of sulfur.

Precipitation of $BaSO_4$ in unreduced iron solutions of carefully regulated acidity gives low values of the order of 0.001 to 0.002 per cent of sulfur.

DETERMINATION OF SULFUR
BY THE
EVOLUTION-TITRATION METHOD.
(ROUTINE.)

APPARATUS.

Use a 500-cc. flask with a delivery tube and a 300-cc. tumbler of tall form (Fig. 3).

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 1).—Mix 500 cc. of HCl (sp. gr. 1.19) and 500 cc. of distilled water.

Ammoniacal Cadmium Chloride.—Dissolve 10 g. of cadmium chloride in 400 cc. of distilled water and add 600 cc. of NH_4OH (sp. gr. 0.90).

Potassium Iodate.—Dissolve 1.116 g. of potassium iodate and 12 g. of potassium iodide in 1000 cc. of distilled water. Standardize with a steel of known sulfur content. Each cubic centimeter should be equivalent to 0.01 per cent of sulfur, when a 5-g. sample is used (see Notes).

Starch.—To 1000 cc. of boiling distilled water, add a cold suspension of 6 g. of starch in 100 cc. of distilled water; cool, add a solution of 6 g. of zinc chloride in 50 cc. of distilled water, and mix thoroughly.

METHOD.

Place 5 g. of steel in the flask and connect the latter as shown in Fig. 3. Place 10 cc. of the ammoniacal cadmium chloride solution and 150 cc. of distilled water in the tumbler. Add 80 cc. of the dilute HCl (1 : 1) to the flask through the thistle tube, heat the flask with its contents gently until the solution of the steel is complete, then boil the solution for ½ minute. Disconnect the delivery tube and remove the tumbler which contains all the sulfur as cadmium sulfide. Add 5 cc. of starch solution and make slightly acid with dilute HCl (1 : 1) and titrate immediately with the standard potassium iodate solution. When a blue color is first obtained, add 20 cc. of dilute HCl (1 : 1) and continue the titration to a permanent faint blue color.

NOTES.

This method succeeds best when all of the conditions are kept constant in the standardization of the iodate solution and in the analysis of the steel.

Some analysts prefer to add the dilute HCl at a temperature of 80 to 90° C. and to heat the flask on an electric heater.

The potassium iodate solution should be standardized against steels of like chemical and physical composition. It is recommended that such steels be used after they have been standardized by the gravimetric method with check gravimetric runs on Bureau of Standards standard steels.

DETERMINATION OF SILICON
BY THE
NITRO-SULFURIC METHOD.

SOLUTIONS REQUIRED.

Nitro-Sulfuric Acid.—Mix 1000 cc. of H_2SO_4 (sp. gr. 1.84), 1500 cc. of HNO_3 (sp. gr. 1.42) and 5500 cc. of distilled water.

Dilute Hydrochloric Acid (5 : 95).—Mix 50 cc. of HCl (sp. gr. 1.19) and 950 cc. of distilled water.

METHOD.

Add cautiously 80 cc. of the nitro-sulfuric acid to 4.676 g. of steel, in a platinum or porcelain dish of 300 cc. capacity, cover with a watch glass, heat until the steel is dissolved and evaporate slowly until copious fumes of sulfuric acid are evolved. Cool, add 125 cc. of distilled water and 5 cc. of HCl (sp. gr. 1.19), heat with frequent stirring until all salts are dissolved and immediately filter on a 9-cm. paper. Wash the precipitate with cold dilute HCl (5 : 95) and hot water alternately to complete the removal of iron salts, and finally with hot water until free from acid. Transfer the filter to a platinum crucible, burn off the paper carefully, finally igniting with the crucible covered over a blast lamp or in a muffle furnace at 1000° C. for at least 10 minutes; cool in a desiccator and weigh. Add sufficient dilute H_2SO_4 (1 : 1) to moisten the silica and then a small amount of hydrofluoric acid. Evaporate to dryness, ignite and weigh. The difference in weights in milligrams divided by 100 equals the percentage of silicon.

NOTE.

A blank determination on all reagents used should be made and the results corrected accordingly.

DETERMINATION OF SILICON
BY THE
SULFURIC ACID METHOD.
(OPTIONAL.)

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (5 : 95).—Mix 50 cc. of HCl (sp. gr. 1.19) and 950 cc. of distilled water.

METHOD.

To 2.338 g. of steel, in a beaker of low form of 500-cc. capacity, add 60 cc. of distilled water, and then cautiously 15 cc. of H_2SO_4 (sp. gr. 1.84). Cover with a watch glass, heat until the steel is dissolved and evaporate until copious fumes of sulfuric acid are evolved. Cool, add 100 cc. of distilled water and heat with frequent stirring until the salts are in solution. Immediately filter on a 9-cm. paper, wash the precipitate with cold dilute HCl (5 : 95), until free from iron, and finally with hot water until free from acid. Ignite and weigh. Add sufficient dilute H_2SO_4 (1 : 1) to moisten the silica and then a small amount of hydrofluoric acid. Evaporate to dryness, ignite and weigh. The difference in weights in milligrams divided by 50 equals the percentage of silicon.

NOTE.

A blank determination on all reagents used should be made and the results corrected accordingly.

DETERMINATION OF COPPER.

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 5).—Slowly stir 200 cc. of H_2SO_4 (sp. gr. 1.84) into 1000 cc. of distilled water.

Dilute Sulfuric Acid (2 : 98).—Mix 20 cc. of H_2SO_4 (sp. gr. 1.84) and 980 cc. of distilled water.

Acidulated Hydrogen Sulfide Water.—Saturate 500 cc. of the above solution with hydrogen sulfide.

Sodium Hydroxide (5-per-cent).—Dissolve 50 g. of stick NaOH in 1000 cc. of distilled water and filter through asbestos if necessary.

Sodium Thiosulfate (50-per-cent).—Dissolve 100 g. of $Na_2S_2O_3 \cdot 5H_2O$ in 100 cc. of distilled water and filter if necessary.

Dilute Nitric Acid (1 : 1).—Mix 500 cc. of HNO_3 (sp. gr. 1.42) and 500 cc. of distilled water.

METHOD.

(a) *Precipitation by Hydrogen Sulfide.*

Dissolve 10.00 g. of steel in 100 cc. of dilute H_2SO_4 (1 : 5), and when solution is complete, dilute to at least 500 cc. with water. Heat to boiling and saturate with H_2S. Digest a while, filter on paper or paper pulp and wash with acidulated hydrogen sulfide water. Ignite the residue and paper in a porcelain crucible and fuse with a small amount of alkali pyrosulfate. Dissolve the cooled melt in the crucible in 1 to 2 cc. of HCl (sp. gr. 1.19) and a few cc. of water, transfer to a 200-cc. beaker, dilute to 100 cc. and add NaOH (5-per-cent) solution in slight excess. Boil, digest, and filter, in order to separate such elements as vanadium, tungsten and molybdenum. Dissolve the precipitate in hot dilute HNO_3 (1 : 1), add 5 cc. of H_2SO_4 (sp. gr. 1.84), evaporate to the appearance of fumes of sulfuric acid, cool, dilute to 40 cc., filter and add 10 cc. of NH_4OH (sp. gr. 0.90). Heat the feebly acid solution to boiling and saturate with H_2S. Digest a while, filter, wash thoroughly with acidulated hydrogen sulfide water, and proceed according to method *1* or *2* below.

(b) *Precipitation by Thiosulfate.*

Transfer 5 g. of the sample to a 600-cc. beaker, add 100 cc. of H_2SO_4 (1 : 5), and heat until the sample is dissolved. Dilute to 300 cc., heat to boiling, add 15 cc. of thiosulfate solution (50-per-cent), and continue the boiling for five minutes or until the precipitate of copper sulfide has coagulated. Collect the precipitate upon an 11-cm. paper and wash *slightly* with dilute H_2SO_4 (2 : 98). Ignite the residue and paper in a porcelain crucible and fuse with a *small* amount of alkali pyrosulfate. Dissolve the cooled melt in the crucible in 1 to 2 cc. of HCl (sp. gr. 1.19) and a few cc. of water, transfer to a 200-cc. beaker, dilute to 100 cc. and add NaOH (5-per-cent) solution in slight excess. Boil, digest and filter in order to separate such elements as vanadium, tungsten and molybdenum. Dissolve the precipitate in hot dilute HNO_3 (1 : 1), carefully add 20 cc. of H_2SO_4 (sp. gr. 1.84), evaporate to the appearance of fumes of H_2SO_4, cool, dilute and filter. Dilute the solution to a volume of 300 cc. and precipitate the copper with thiosulfate as above. Filter, wash with dilute H_2SO_4 (2 : 98) until sodium salts have been removed and proceed according to method *1* or *2* below.

(*1*) *Electrolytic Method.*

Dissolve the sulfides obtained as above in hot dilute HNO_3 (1 : 1), and electrolyze after the addition of H_2SO_4 according to usual procedures.

(*2*) *Gravimetric Method.*

Ignite the sulfides obtained as above and weigh as copper oxide.

As this compound is somewhat hygroscopic, care must be observed to prevent the absorption of moisture.

DETERMINATION OF COPPER.

(ROUTINE.)

SOLUTIONS REQUIRED.

Potassium Ferrocyanide.—Dissolve 10 g. of potassium ferrocyanide in 100 cc. of distilled water.

Standard Copper Nitrate.—Dissolve 2 g. of purest electrolytic copper in 20 cc. of HNO_3 (1 : 1), and dilute to 1000 cc. with distilled water. Each cubic centimeter is equivalent to 0.02 per cent of copper on the basis of a 10-g. sample.

METHOD.

Proceed as in (*a*) Precipitation by Hydrogen Sulfide or (*b*) Precipitation by Thiosulfate, under "Determination of Copper" until the alkali pyrosulfate fusion has been made. Extract the cooled melt with hot water, filter, and complete the determination colorimetrically as follows:

Evaporate the filtrate to about 25 cc., make faintly ammoniacal, filter into a 100-cc. Nessler tube and wash with hot water.

(*a*) *If the solution is a strong blue,*

To another 100-cc Nessler tube add 50 cc. of distilled water, 5 cc. of NH_4OH (sp. gr. 0.90) and from a burette the standard copper nitrate solution until the blue colors match.

(*b*) *If the solution is a faint blue,*

To the filtrate in a Nessler tube add dilute H_2SO_4 (1 : 5) to faint acidity and then a few drops of the potassium ferrocyanide solution. To another 100-cc. Nessler tube add 50 cc. of distilled water, a few drops of the potassium ferrocyanide solution, and from a burette the standard copper nitrate solution until the reddish brown colors match.

DETERMINATION OF NICKEL.

See the Determination of Nickel in Nickel Steel by the Gravitric Dimethylglyoxime Method.[1]

See the Determination of Nickel in Nickel Steel by the Cyanide Titration Method (Routine).[1]

DETERMINATION OF CHROMIUM.

See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

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[1] Tentative Methods of Chemical Analysis of Alloy Steels (Serial Designation: A 55 – 22 T), p. 600.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF ALLOY STEELS.[1]

Serial Designation: A 55 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

SILICO-MANGANESE STEEL.

All determinations are carried out as in the Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 – 22 T) of the American Society for Testing Materials.[2]

NICKEL STEEL.

DETERMINATION OF CARBON.

See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.[3]

DETERMINATION OF MANGANESE.

See the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.[3]

See the Determination of Manganese in Plain Carbon Steel by the Persulfate Method (Routine).[3]

DETERMINATION OF PHOSPHORUS.

See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[3]

See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[3]

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[1] These methods, when adopted as standard, will supersede the present Standard Methods of Chemical Analysis of Alloy Steels (Serial Designation: A 55 – 15), 1921 Book of A.S.T.M. Standards.

Criticisms of these Tentative Methods are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

[2] See p. 578.

[3] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 – 22 T), p. 578.

DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.[1]

See the Determination of Sulfur in Plain Carbon Steel by the Evolution Titration Method (Routine).[1]

NOTES.

The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten or molybdenum or more than 0.4 per cent of copper.

DETERMINATION OF SILICON.

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.[1]

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric Acid Method (Optional).[1]

DETERMINATION OF NICKEL
BY THE
GRAVIMETRIC DIMETHYLGLYOXIME METHOD

SOLUTIONS REQUIRED.

Dilute Nitric Acid (1 : 3)—Mix 250 cc. of HNO_3 (sp. gr. 1.42) with 750 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 1).—Mix 500 cc. of HCl (sp. gr. 1.19) and 500 cc. of distilled water.

Dimethylglyoxime (1-per-cent).—Dissolve 20 g. of dimethylglyoxime in 1300 cc. of NH_4OH (sp. gr. 0.90) and dilute to 2000 cc. Ten cubic centimeters of this solution allow sufficient excess to completely precipitate 0.015 g. of nickel.

METHOD.

For ordinary nickel steel take a 1-g. sample; with less than 0.10 or more than 5 per cent nickel, larger or smaller samples may be taken. In the presence of less than 0.5 per cent chromium dissolve the sample in 50 cc. of hot dilute HNO_3 (1 : 3). When chromium is present in amounts greater than 0.5 per cent or under circumstances where chromium carbides are present, dissolve the sample in 60 cc. of dilute HCl (1 : 1) with the aid of heat and then oxidize the iron and the carbides by adding HNO_3 (sp. gr. 1.42) drop by drop, until effervescence ceases. Boil to remove the products resulting from the decomposition of the HNO_3 and then cool the solution. Add in succession, with stirring after each addition, 12 g. of citric acid or equivalent solution, 20 cc. of NH_4OH (sp. gr. 0.90), sufficient solution of dimethylglyoxime to precipitate all nickel present and finally enough more NH_4OH to make the solution distinctly ammoniacal. The solution will usually have a volume of 200 to 250 cc. and precipitation is complete immediately if the amount of nickel is over 0.10 per cent. With less nickel or in umpire analyses, digestion for one hour is desirable. Stir the solution thoroughly and filter on an asbestos mat on a 2-in. perforated porcelain plate or a Büchner funnel, avoiding strong suction and taking care that the funnel always remains partly filled with liquid. Thoroughly wash the precipitate with water, discard the filtrate and washings, rinse the funnel stem and then with the mat still in place and with suction off, add 25 cc. of a mixture of 20 cc. of HCl (sp. gr. 1.19) and 5 cc. of HNO_3 (sp. gr. 1.42). After one minute, apply suction till dry, repeat the treatment with 25 cc. of the mixture, drain, and wash thoroughly with water. Transfer the solution to a 400-cc. beaker and evaporate the solution to 100 cc. Filter if necessary and repeat the precipitation of the glyoxime by adding 5 g. citric acid, nearly neutralizing the absolutely clear solution with NH_4OH (sp. gr. 0.90) and then adding dimethylglyoxime and NH_4OH as before. Finally filter on a weighed Gooch crucible, thoroughly wash with hot water, dry at 110 to 120° C. and weigh. The precipitate contains 20.31 per cent of nickel.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

NOTES.

Direct weighing of the precipitate is desirable when small amounts of nickel are concerned. Large precipitates are more conveniently ignited at red heat to NiO. In this case, care must be taken to prevent sublimation of the undecomposed salt. This may be accomplished by enclosing the wet paper and precipitate in one or two wet ashless papers and slowly igniting so that the papers char before taking fire. In this way the compound is decomposed and ignition may proceed at full red heat.

It is difficult to precipitate nickel and to obtain it free from cobalt. when cobalt is preponderant. Complete precipitation may be obtained by adding sufficient dimethylglyoxime to react with both cobalt and nickel and digesting for a longer period, or by oxidizing the cobalt to the trivalent condition by means of $NaClO_3$ or $(NH_4)_2S_2O_8$ in ammoniacal solution before precipitating with dimethylglyoxime. In either case, the first precipitate should be filtered off, dissolved and reprecipitated

DETERMINATION OF NICKEL
BY THE
CYANIDE TITRATION METHOD.

I. PRELIMINARY TREATMENT.

The cyanide titration may be performed in a solution prepared as in (*a*), (*b*), or (*c*) below:

(*a*) *Preliminary Separation with Dimethylglyoxime.* (Presence of chromium, copper, cobalt and small amounts of tungsten.)

Proceed as in the gravimetric method until the dimethylglyoxime precipitate has been dissolved in aqua regia, and then evaporate the solution to 50 cc. or until free from dimethylglyoxime and oxidizing gases. Cool the solution, with ice if desired, neutralize with NH_4OH (sp. gr. 0.90) (rosolic acid is a convenient indicator), add 5 cc. in excess, dilute to 250 cc., and proceed as in the final titration below.

(*b*) *Preliminary Ether Extraction.* (Absence of cobalt and more than 1 per cent tungsten.)

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (3 : 2).—Mix 600 cc. of HCl (sp. gr. 1.19) and 400 cc. of distilled water.

Acidulated Hydrogen Sulfide Water.—Add 25 cc. of HCl (sp. gr. 1.19) to 500 cc. of distilled water and saturate with H_2S.

METHOD.

In a 150-cc. beaker dissolve 1 g. of the steel in 20 cc. of the dilute HCl (3 : 2), add about 2 cc. of HNO_3 (sp. gr. 1.42) to oxidize the iron, and boil to expel the oxides of nitrogen. Cool, and transfer the solution into an 8-oz. separatory funnel, rinsing the beaker with small portions of the dilute HCl (3 : 2). Add 50. cc of ether, shake for 5 minutes, let settle for 1 minute, and then draw off the lower clear solution into another 8-oz. separatory funnel. Add 10 cc. of dilute HCl (3 : 2) to the solution in the first separatory funnel, cool, shake thoroughly, allow to settle for 1 minute, and then draw off the lower clear solution into the second separatory funnel. To the combined solutions in the second separatory funnel add 50 cc. of ether, shake for 5 minutes, let settle for 1 minute, and then draw off the clear layer into a 150-cc. beaker. Heat the aqueous solution gently to expel the ether, add 0.2 g. of potassium chlorate, boil until the chlorate is decomposed, dilute to 100 cc. with hot water, make faintly ammoniacal, and boil for 5 minutes. Filter and wash with hot water.

To the filtrate add 10 cc. of HCl (sp. gr. 1.19) heat just short of boiling and precipitate the copper with hydrogen sulfide. Filter and wash with acidulated hydrogen sulfide water. Boil the filtrate to expel hydrogen sulfide, neutralize with ammonia as in (*a*), add 5 cc. in excess, dilute to 250 cc. and proceed as in the final titration below.

(*c*) ***Direct Titration*** (Absence of copper, cobalt, and more than 1 per cent of tungsten).

SOLUTIONS REQUIRED.

Dilute Nitric Acid (sp. gr. 1.20).—Mix 380 cc. of HNO_3 (sp. gr. 1.42) and 620 cc. of distilled water.

Ammonium Persulfate (15-per-cent).—Make up as needed by dissolving 15 g. of the salt in 100 cc. of distilled water.

Dilute Ammonia (1 : 1).—Mix equal volumes of NH_4OH (sp. gr. 0.90) and distilled water.

Sulfuric-Citric Acids.—Dissolve 200 g. of citric acid in a cooled mixture of 100 cc. H_2SO_4 (sp. gr. 1.84) and 900 cc. of distilled water.

METHOD.

Transfer 1 g. of the sample to a 400-cc. beaker, treat with 20 cc. of dilute HNO_3 (sp. gr. 1.20) and heat until the sample is dissolved. Add 8 to 10 cc. of ammonium persulfate solution (15-per-cent) and continue the boiling for five minutes. Cool the solution, add 50 cc. of the sulfuric-citric acid mixture, and then dilute NH_4OH (1 : 1) until the solution is just alkaline to litmus, when an excess of 5 cc. is added. In case a precipitate is formed, use more citric acid. The neutralization of the solution should be made as soon as possible after the addition of the citric acid, as otherwise this may reduce traces of iron. Cool to room temperature, dilute to 250 cc. and proceed as in the final titration below.

NOTE.

If chromium is present in amounts over 1 per cent, dissolve the steel in 20 cc. of dilute H_2SO_4 (1 : 4), oxidize with 5 cc. of HNO_3 (sp. gr. 1.42), boil 5 minutes cool, add 50 cc. of sulfuric-citric acid mixture and proceed as above

II. FINAL TITRATION.

SOLUTIONS REQUIRED.

Potassium Iodide (10-per-cent).—Dissolve 10 g. of KI in 100 cc. of distilled water.

Standard Silver Nitrate.—Dissolve 5.7903 g. of $AgNO_3$ in distilled water and dilute to exactly 1000 cc.

Standard Potassium Cyanide.—Dissolve 4.5 g. of KCN in 1000 cc. of distilled water containing 1 g. of KOH. Standardize this solution against the standard silver nitrate solution as follows: To a 400-cc. beaker add 100 cc. of water, 3 cc. of NH_4OH, 2 cc. of potassium iodide solution (10-per-cent), and finally 30 cc. of silver nitrate solution from a burette. Titrate with the cyanide solution until the solution is perfectly clear, and then add more silver nitrate solution until a faint cloudiness is obtained which can be dispelled by two drops of the cyanide solution. Adjust the cyanide solution so that it is equivalent to the silver nitrate solution and check the theoretical value (0.001 g. nickel) by standardizing, by the procedure chosen, against a steel of known nickel content as determined by the gravimetric dimethylglyoxime method.

METHOD.

Add 2 cc. of potassium iodide solution (10-per-cent) to the solution prepared as in (*a*), (*b*), or (*c*) and then from a burette add 3 cc. of standard silver nitrate solution. Slowly add standard cyanide solution, with constant stirring, until the solution is perfectly clear. Continue the addition of the silver nitrate solution and titration with cyanide solution until the cloudiness of the solution, due to the addition of two drops of the standard silver nitrate, is just expelled by the final addition of two drops of the standard cyanide. Each cubic centimeter excess of standard cyanide solution required over standard silver nitrate solution used in the titration represents 0.1 per cent of nickel.

NOTE.

If cobalt is present, an unsatisfactory end point will be obtained if the titration is carried out as directed after a preliminary separation by methods (*b*) or (*c*). Cobalt may, however, be titrated satisfactorily provided it is first oxidized to the trivalent condition by boiling the ammoniacal solution with $NaClO_3$ prior to the titration with cyanide. In this case, the compound $K_2Co(CN)_6$ is formed and the titration represents the combined effect of nickel and cobalt. (See the Determination of Cobalt in Tungsten Steel by the Cyanide Titration Method (Routine)).[1]

CHROME-NICKEL STEEL.

DETERMINATION OF CARBON.

See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.[2]

NOTE.

Difficultly combustible high-chromium steel can usually be burned directly if the sample is heated for a few minutes before admitting oxygen. A high temperature (1100° C.) is desirable, and in extreme cases complete combustion can be had by mixing the drillings with low-carbon iron or steel.

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[1] See p. 633.

[2] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

DETERMINATION OF MANGANESE
BY THE
HYDROLYSIS-BISMUTHATE METHOD.
(ABSENCE OF COBALT.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 9).—Pour 100 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with stirring into 900 cc. of distilled water.

Sodium Bicarbonate (8-per-cent).—Dissolve 80 g. of $NaHCO_3$ in 1000 cc. of distilled water.

Dilute Nitric Acid (3 : 97).—Mix 30 cc. of HNO_3 (sp. gr. 1.42) and 970 cc. of distilled water.

Ferrous Sulfate.—See the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.[1]

Standard Potassium Permanganate.—See the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.[1]

METHOD.

Dissolve 1.000 g. of the sample contained in a 200-cc. covered Erlenmeyer flask in 20 cc. of dilute H_2SO_4 (1 : 9). When action is complete, dilute to 100 cc. with boiling water. Add from a burette sodium bicarbonate solution (8-per-cent) until a permanent precipitate is formed (approximately 36 cc.) and then 4 cc. more. Boil one minute, allow to settle and filter on a rapid filter, washing 4 to 5 times with boiling water. If the precipitation has been properly performed there will be no more precipitate than can be conveniently handled on a 9-cm. paper. The filtrate will become cloudy in the funnel stem and in the receiving vessel, owing to oxidation and hydrolysis. Heat the filtrate to boiling and oxidize with HNO_3 (sp. gr. 1.42), adding in all 12 cc. Evaporate to about 25 cc., cool to 15° C., and add an excess of sodium bismuthate. Let stand for a few minutes, add 50 cc. of dilute HNO_3 (3 : 97), and filter through asbestos. Wash with the same acid until the washings run through colorless. Add 3 cc. of H_3PO_4 (sp. gr. 1.71) and titrate with ferrous sulfate and standard potassium permanganate, as in the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.[1]

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

NOTE.

The bicarbonate precipitate does not ordinarily contain more than small amounts (about 0.005 per cent) of manganese. In very accurate work this should be recovered by transferring the precipitate to a beaker, dissolving it in aqua regia, fuming with sulfuric acid, and then adding sodium hydroxide and sodium peroxide and boiling. Chromium and vanadium are thus separated from manganese and iron which should be filtered off, dissolved in 5 cc. of HNO_3 (1 : 1) and added to the filtrate from the bicarbonate precipitation. A drop of sulfurous acid added to the nitric acid aids in the solution of the manganese dioxide.

DETERMINATION OF MANGANESE

BY THE

PERSULFATE METHOD.

(ROUTINE AND IN PRESENCE OF COBALT.)

See the Determination of Manganese in Plain Carbon Steel by the Persulfate Method (Routine).[1]

NOTE.

In making the titration special care should be given to standardizing the end-point reading and the reading should be corrected by a blank, which varies with the amount of chromium present.

DETERMINATION OF PHOSPHORUS.

See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method.[1]

DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.[1]

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).[1]

NOTES.

The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten or molybdenum or more than 0.4 per cent of copper.

The annealing of the steel drillings has been found by a number of investigators to increase the degree of refinement of the method.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

DETERMINATION OF SILICON.

(*a*) *Low Chromium.*

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.[1]

(*b*) *High Chromium.*

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 9).—Pour 100 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with stirring into 900 cc. of distilled water.

Dilute Hydrochloric Acid (5 : 95).—Mix 50 cc. of HCl (sp. gr. 1.19) and 950 cc. of distilled water.

METHOD.

Dissolve 2.338 g. of the sample in a covered porcelain dish in 30 cc. of HCl (sp. gr. 1.19) or 100 cc. of dilute sulfuric acid (1 : 9). If vanadium or molybdenum is present, add a few crystals of sodium chlorate when the action is complete, boil, and then evaporate to low bulk. If sulfuric acid has not been added, cautiously add 15 cc. of H_2SO_4 (sp. gr. 1.84) and continue the evaporation until fumes of H_2SO_4 are copiously evolved. Cool, dilute with 125 cc. of distilled water, add 5 cc. of HCl (sp. gr. 1.19) and warm gently with frequent stirring until the soluble salts have dissolved. Immediately filter through an 11-cm. filter paper, wash with dilute HCl (5 : 95) until free from iron and then with hot water until free from acid. Transfer the filter to a platinum crucible, burn off the paper carefully and finally ignite, with the crucible covered, over a blast lamp or in a muffle furnace at 1000° C. for at least 10 minutes. Cool in a desiccator and weigh. Add sufficient dilute H_2SO_4 (1 : 1) to moisten the silica, and then a small amount of HF. Evaporate to dryness, ignite and weigh. The difference in weights represents the amount of silica.

NOTE.

A blank determination on all reagents used should be made and the results corrected accordingly.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33-22 T), p. 578.

DETERMINATION OF CHROMIUM

BY THE

PERSULFATE OXIDATION METHOD.

SOLUTIONS REQUIRED.

Sulfuric-Phosphoric Acid Mixture.—Mix 320 cc. of H_2SO_4 (1 : 1), 80 cc. of H_3PO_4 (85-per-cent) and 600 cc. of distilled water.

Dilute Nitric Acid (sp. gr. 1.20).—Mix 380 cc. of HNO_3 (sp. gr. 1.42) and 620 cc. of distilled water.

Silver Nitrate (2.5-per-cent).—Dissolve 25 g. of $AgNO_3$ in 1000 cc. of distilled water.

Ammonium Persulfate (15-per-cent)—Make up as needed by dissolving 15 g. of the salt in 100 cc. of distilled water.

Sodium Chloride (5-per-cent).—Dissolve 50 g. of NaCl in 1000 cc. of distilled water.

Standard Ferrous Sulfate.—Dissolve 12 g. of ferrous ammonium sulfate in a cold mixture of 50 cc. of H_2SO_4 (sp. gr. 1.84) and 950 cc. of distilled water. This solution is preferably adjusted so that it is exactly equivalent to the permanganate solution which is used.

Standard Permanganate Solution.—Dissolve 0.95 g. of $KMnO_4$ in 1000 cc. of distilled water, allow to age for at least one week and filter through purified asbestos. When much work is done, a desirable method of preparing the solution consists in aging large volumes of two solutions, one slightly stronger than the above and one about one-fifth as strong. Clear, one to two-liter portions of these aged solutions may then be siphoned off, standardized and mixed to get the desired titre. Standardize the permanganate solution against the Bureau of Standards Standard Sodium Oxalate Sample No. 40*a* as follows:

In a 200-cc. beaker dissolve 0.075 to 0.10 g. of sodium oxalate in 75 cc. of hot water (80 to 90° C.) and add 5 cc. of dilute H_2SO_4 (1 : 1). Titrate at once with the permanganate solution, stirring the liquid vigorously and continuously. The permanganate must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate used to cause an end point color must be estimated by matching the color in another beaker containing the same bulk of acid and hot water. The temperature of the solution should not be below 60° C. by the time the end point is reached.

METHOD.

Transfer 2 g. of the sample to a 600-cc. beaker and add 60 cc. of sulfuric-phosphoric acid mixture. Heat until all action ceases, add 10 cc. of HNO_3 (sp. gr. 1.20), and boil until solution is complete and oxides of nitrogen are expelled. Add silver nitrate solution (2.5-per-cent) in amount equal to 0.3 g. of the salt for each 1.5 per cent of chromium present. Dilute to 300 cc. with boiling water, heat to boiling, and add 8 cc. of ammonium persulfate solution (15-per-cent). When the permanganate color has developed, add 5 cc. of sodium chloride solution (5-per-cent) and boil until the pink color disappears and the persulfate is decomposed, which requires about 10 minutes. Cool the solution, dilute to approximately 400 cc. and titrate for chromium as follows: Add a measured excess of standard ferrous sulfate solution (50 cc. for less than 1.5 per cent chromium, 100 cc. for 1.5 to 3 per cent chromium) and then titrate with the standard potassium permanganate solution until an end point is obtained which is permanent upon continued stirring for at least one minute. The titration must be corrected for dilution and color effect. If no chromium or nickel were present the dilution effect alone would be involved and satisfactorily eliminated by titrating the same volume of ferrous sulfate solution in a solution of like volume and acidity. In colored solutions the correction can be made (1) empirically, as judged by experience; (2) by titration of the same volume of ferrous sulfate in a solution of like volume and acidity and containing the same amount of the coloring elements in their final valency; or (3) in the final titrated solution. The last is the most convenient and satisfactory and may be performed by destroying the slight excess of permanganate which is present in the titrated solution by a few drops of hydrogen peroxide, boiling until the excess of peroxide and the pervanadate are destroyed (10 minutes actual boiling), cooling to room temperature, and then titrating with the permanganate solution. The difference between the volumes of permanganate used is then a true oxidizing equivalent of the excess of ferrous sulfate employed and the percentage of chromium may be calculated in the usual manner. The final solution may be preserved for the determination of vanadium as described in the Determination of Vanadium in Chrome-Vanadium Steel by Reduction with Ferrous Sulfate and Titration with Permanganate Method (Routine).[1]

DETERMINATION OF NICKEL.

See the Determination of Nickel in Nickel Steel by the Gravimetric Dimethylglyoxime Method.[2]

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[1] See p. 617.

[2] See p. 601.

See the Determination of Nickel in Nickel Steel by the Cyanide Titration Method.[1]

VANADIUM STEEL.

All determinations are carried out as in the methods of chemical analysis of Chrome-Vanadium Steel.

CHROME-VANADIUM STEEL.

DETERMINATION OF CARBON.

See Determination of Carbon in Chrome-Nickel Steel.[2]

DETERMINATION OF MANGANESE.

See the Determination of Manganese in Chrome-Nickel Steel by the Hydrolysis-Bismuthate Method.[3]

See the Determination of Manganese in Chrome-Nickel Steel by the Persulfate Method (Routine).[4]

DETERMINATION OF PHOSPHORUS BY THE MODIFIED MOLYBDATE-MAGNESIA METHOD.

SOLUTIONS REQUIRED.

Dilute Nitric Acid (sp. gr. 1.20).—Mix 380 cc. of HNO_3 (sp. gr. 1.42) and 620 cc. of distilled water.

Dilute Nitric Acid (2 : 100).—Mix 20 cc. of HNO_3 (sp. gr. 1.42) and 1000 cc. of distilled water.

Potassium Permanganate (2.5-per-cent).—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[5]

Ammonium Bisulfite (3-per-cent).—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[5]

Ammonium Molybdate.—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[5]

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[1] See p. 603.

[2] See p. 605.

[3] See p. 606.

[4] See p. 607.

[5] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

Magnesia Mixture.—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

Dilute Ammonium Hydroxide (1 : 2).—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

Dilute Ammonium Hydroxide (1 : 19).—See the Determination of Phosphorous in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

Ferrous Sulfate.—Dissolve 40 g. of ferrous sulfate in 100 cc. of distilled water that has been acidified with 1 cc. of H_2SO_4 (sp. gr. 1.84)

METHOD.

In a 300-cc. Erlenmeyer flask dissolve 5 g. of steel in 75 cc. of dilute HNO_3 (sp. gr. 1.20). Heat, and while boiling, add about 12 cc. of potassium permanganate solution (2.5-per-cent), and continue boiling until manganese dioxide precipitates. Dissolve the precipitate by additions of ammonium bisulfite solution (3-per-cent) or ferrous sulfate solution, boil until clear and free from oxides of nitrogen. Cool to 15 to 20° C., add 5 cc. of the ferrous sulfate solution, and 2 or 3 drops of concentrated sulfurous acid, and then 100 cc. of the ammonium-molybdate solution. Shake or agitate thoroughly for 5 minutes, allow to settle for at least 30 minutes, filter on a 9-cm. paper and wash the flask and precipitate at least 3 times with dilute HNO_3 (2 : 100) to free from iron. Treat the precipitate on the filter with dilute NH_4OH (1 : 2), letting the solution run into the original flask and avoiding the use of more than 10 to 20 cc. of the reagent. Pour a solution of 0.5 g. of citric acid in 15 cc. of water and 10 cc. of HCl (sp. gr 1.19) through the filter in order to dissolve any ferric phosphate on the paper and render acid the ammoniacal solution of the phosphate. Transfer the solution to a 100-cc. beaker, add 10 cc. of the magnesia mixture, and precipitate the phosphate by adding ammonium hydroxide (sp. gr. 0.90) slowly and with constant stirring, until a crystallin precipitate is formed or the solution is alkaline. Finally add 10 per cent by volume in excess. Set aside in a cool place for from 2 to 6 hours, filter and wash with dilute NH_4OH (1 : 19). Ignite and weigh. Dissolve the precipitate of magnesium pyrophosphate with 5 cc. of dilute HNO_3 (sp. gr. 1.20) and 20 cc. of water, filter and wash with hot water. Ignite and weigh. The difference in weights represents pure magnesium pryophosphate containing 27.87 per cent of phosphorus.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33-22 T), p. 578.

NOTE.

The ammonium-molybdate solution should be kept in a cool place and should always be absolutely clear before using.

If arsenic is present in the steel, it will come down in part with the phosphomolybdate and contaminate the pyrophosphate. In very accurate work or when arsenic is present in appreciable amount, steps must be taken for its removal before precipitation with magnesia mixture.

DETERMINATION OF PHOSPHORUS

BY THE

MODIFIED ALKALIMETRIC METHOD.

(ROUTINE.)

SOLUTIONS REQUIRED.

Dilute Nitric Acid (sp. gr. 1.20).—See the Determination of Phosphorus by the Modified Molybdate-Magnesia Method.[1]

Dilute Nitric Acid for Washing (2 : 100).—See the Determination of Phosphorus by the Modified Molybdate-Magnesia Method.[1]

Potassium Permanganate (2.5-per-cent).—See the Determination of Phosphorus by the Modified Molybdate-Magnesia Method.[1]

Ammonium Bisulfite (3-per-cent).—See the Determination of Phosphorus by the Modified Molybdate-Magnesia Method.[1]

Ammonium Molybdate.—See the Determination of Phosphorus by the Modified Molybdate-Magnesia Method.[1]

Ferrous Sulfate.—See the Determination of Phosphorus by the Modified Molybdate-Magnesia Method.[1]

Potassium Nitrate (1-per-cent).—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[2]

Phenolphthalein Indicator.—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[2]

Standard Sodium Hydroxide.—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[2]

Standard Nitric Acid.—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[2]

METHOD.

In a 300-cc. Erlenmeyer flask, dissolve 2 g. of steel in 50 cc. of dilute HNO_3 (sp. gr. 1.20). Heat, and while boiling add 6 cc. of potassium permanganate solution (2.5-per-cent) and continue boiling until manganese dioxide precipitates. Dissolve this precipitate by additions of the ammonium bisulfite solution (3-per-cent) or ferrous sulfate solution, boil until clear and free from oxides of nitrogen and cool to 15 to 20° C. Add 5 cc. of the ferrous sulfate solution and 2 or 3 drops of concentrated sulfurous acid, and then 50 cc. of the ammonium-molybdate solution. Shake or agitate for 5 minutes, allow to settle for at least 30 minutes, filter on a 9-cm. paper, wash the precipitate and flask three times with dilute HNO_3 (2 : 100) to free it from iron, and continue the washing with the potassium nitrate solution (1-per-cent) until the precipitate and flash are free from acid.

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[1] See p. 611.

[2] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

Transfer the paper and precipitate to the solution flask, add 20 cc. of distilled water (see Notes), 5 drops of phenolphthalein solution as indicator, and an excess of the standard sodium hydroxide solution. Insert a rubber stopper and shake vigorously until solution of the precipitate is complete. Wash off the stopper with distilled water and determine the excess of standard sodium hydroxide solution by titrating with standard nitric acid solution. Each cubic centimeter of standard sodium hydroxide solution represents 0.01 per cent of phosphorus.

NOTES.

The ammonium molybdate solution should be kept in a cool place and should always be absolutely clear before using.

All distilled water used in titration should be freed from carbon dioxide by boiling or otherwise.

Bureau of Standards Standard Steel No. *30b* or its renewal is recommended as a suitable steel for standardizing the sodium hydroxide solution.

DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.[1]

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).[1]

NOTES.

The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten or molybdenum or more than 0.4 per cent of copper.

The annealing of the steel drillings has been found by a number of investigators to increase the degree of refinement of the method.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

DETERMINATION OF SILICON.

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.[1]

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric-Acid Method (Optional).[1]

DETERMINATION OF CHROMIUM.

See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[2] Reserve the titrated solution for the Determination of Vanadium by Reduction with Ferrous Sulfate and Titration with Permanganate (Routine).

DETERMINATION OF VANADIUM
BY THE
ELECTROLYTIC SEPARATION METHOD.

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 9).—Carefully mix 100 c.c of H_2SO_4 (sp. gr. 1.84) and 900 cc. of distilled water.

Dilute Sulfuric Acid (1 : 1).—Add 500 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with stirring to 500 cc. of distilled water.

Sodium Bicarbonate (8-per-cent).—Dissolve 80 g. of $NaHCO_3$ in 1000 cc. of distilled water.

Potassium Ferricyanide.—Prepare a very dilute solution as needed, by dissolving a crystal the size of the head of a pin in 25 cc. of distilled water.

Standard Potassium Permanganate.—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[2]

METHOD.

Dissolve 2 g. of the sample, contained in a 200-cc. covered Erlenmeyer flask, in 30 cc. of dilute H_2SO_4 (1 : 9). When action is complete, dilute to 100 cc. with boiling water, heat to boiling, and add sodium bicarbonate solution (8-per-cent) from a burette until a permanent precipitate appears (approximately 36 cc.) and then 4 cc. more. Let settle, filter on a rapid filter and quickly wash the flask and precipitate with hot water. If the precipitation has been properly performed there will be no more precipitate than can be conveniently handled on a 9-cm. paper. The filtrate will become cloudy in the funnel stem and in the receiving vessel, owing to oxidation and hydrolysis. (If the flask, paper and precipitate have been well washed, the filtrate will contain all but traces of the manganese in the sample free from chromium and vanadium, and therefore, it may be oxidized with nitric acid and the manganese determined by the bismuthate or persulfate methods.) Place the paper and precipitate in the original flask, add 20 cc. of HNO_3 (sp. gr. 1.42) shake until the paper is broken up, and then add 5 cc. of H_2SO_4 (sp. gr. 1.84). Heat over a free flame until fumes of sulfuric acid are given off, cool, and then add more HNO_3 and repeat the heating in case the organic matter has not been destroyed. Finally cool, wash down the sides of the flask, and evaporate again to the appearance of fumes of sulfuric acid and until all of the nitric acid has been expelled. Cool, dilute to 40 cc. and nearly neutralize the solution with NH_4OH (sp. gr. 0.90). Transfer the weakly acid solution to the electrolyzing apparatus, rinsing the flask with small portions of water and keeping the total volume of the solution down to 70 cc. The electrolysis may be performed with a mercury cathode in (1) a special modified separatory funnel,[1] (2) in a small beaker with sealed-in platinum wire,[2] or (3) in an ordinary beaker with the cathode wire enclosed in a glass tube extending into the mercury. In any case, the cathode wire should be imbedded in about 200 g. of mercury, and the solution electrolyzed (preferably with a stirring arrangement) using a current of 5 to 6 amperes at 6 to 7 volts. Continue the electrolysis (ordinarily 15 to 20 minutes if the solution is stirred) until iron is absent as indicated by a ferricyanide test on a small drop of the electrolyte. When iron is absent, remove the electrolyte and wash the mercury two or three times with 25 to 30 cc. of water while the current is continued. The solution must now give no test for iron. Add 2 to 3 cc. of dilute H_2SO_4 (1 : 1), heat to 70 to 80° C., and add permanganate solution to a strong pink color. Run sulfur dioxide into the boiling solution for a few minutes until the vanadium is reduced, and then a rapid stream of carbon dioxide until the escaping steam gives no test for SO_2. Cool the solution to 70 to 80° C. and titrate with the standard permanganate solution. Repeat the reduction and titration until concordant results are obtained. The titration should be corrected by a blank determination on a solution of like volume and acidity.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

[2] See p. 609.

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[1] Reprint 161 from the *Bulletin* of the Bureau of Standards, Vol. 7, No. 3; *Journal Industrial and Engineering Chemistry*, Vol. 3, p. 476 (1911).

[2] Smith, Electroanalysis, Fifth Edition, P. Blakiston's Son and Co., p. 63.

DETERMINATION OF VANADIUM
BY
REDUCTION WITH FERROUS SULFATE AND TITRATION WITH PERMANGANATE.

(ROUTINE.)

SOLUTIONS REQUIRED.

Sulfuric-Phosphoric Acid Mixture.—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

Dilute Nitric Acid (1 : 1).—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

Silver Nitrate (2.5-per-cent).—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

Ammonium Persulfate (15-per-cent).—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

Sodium Chloride (5-per-cent).—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

Standard Ferrous Sulfate.—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

Standard Potassium Permanganate.—See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

METHOD.

See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

Use the solution employed for the determination of chromium and add 10 cc. of ferrous sulfate solution if vanadium is under 0.80 per cent, and 20 cc. if the vanadium content is higher. Stir the solution thoroughly, add 8 cc. of ammonium persulfate solution (15-per-cent) and stir for one minute. Titrate with the standard permanganate solution to a definite pink color which does not fade upon continued stirring for one minute. In this determination the ferrous sulfate reduces the vanadium, the persulfate oxidizes the excess of ferrous sulfate but does not oxidize the reduced vanadium and the reduced vanadium is oxidized by permanganate which does not react with the excess of persulfate. As in the determination of chromium, an excess of permanganate is used in order to overcome the dilution effect and the color interference, and the same blank correction should be subtracted as was there found.

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[1] See p. 609.

TUNGSTEN STEEL.

DETERMINATION OF CARBON.

See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.[1]

NOTE.

Difficultly combustible tungsten steel can often be burned directly if the sample is heated for a few minutes before admitting oxygen. A high temperature (1100° C.) is desirable, and in extreme cases complete combustion can be had by mixing the sample with low-carbon iron or steel.

DETERMINATION OF MANGANESE
BY THE
HYDROLYSIS-BISMUTHATE METHOD.
(ABSENCE OF COBALT.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 4).—Pour 200 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with constant stirring, into 800 cc. of distilled water.

Dilute Sulfuric Acid (5 : 95).—Pour 50 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with stirring, into 950 cc. of distilled water.

Sodium Carbonate (8-per-cent).—Dissolve 80 g. of Na_2CO_3 in 1000 cc. of distilled water.

Dilute Nitric Acid (3 : 97).—See the Determination of Manganese in Plain Carbon Steel by the Bismuthate-Ferrous Sulfate Method.[1]

Standard Ferrous Sulfate.—See the Determination of Manganese in Plain Carbon Steel by the Bismuthate-Ferrous Sulfate Method.[1]

Standard Potassium Permanganate.—See the Determination of Manganese in Plain Carbon Steel by the Bismuthate-Ferrous Sulfate Method.[1]

METHOD.

In a covered 150-cc. beaker, dissolve 1 g. of the sample in 30 cc. of dilute H_2SO_4 (1 : 4). When solution is complete, dilute to 50 cc., filter through a small paper into a 250-cc. Erlenmeyer flask, wash with a little dilute H_2SO_4 (5 : 95), and reserve the residue. Add a pinch of Na_2CO_3 to the solution to provide a non-oxidizing atmosphere, cover the flask and set aside. Quickly ignite the insoluble matter in a porcelain crucible, fuse with a little alkali pyrosulfate, take up the melt in a very little dilute H_2SO_4 (5 : 95), filter, and add the filtrate to the reserved filtrate. Dilute the combined solutions to 100 cc., boil, and add sodium carbonate solution (8-per-cent) from a burette until a permanent precipitate appears and then 4 cc. more. Boil for one minute, let settle, filter *rapidly* and wash well with hot water. The precipitate should be no larger than can be conveniently handled on a 9-cm. paper and the filtrate will become cloudy owing to oxidation and hydrolysis. Add 15 cc. of HNO_3 (sp. gr. 1.42) to the filtrate, heat to boiling, and evaporate to approximately 50 cc. Cool to room temperature, add an excess of sodium bismuthate, agitate for a few minutes, add 50 cc. of dilute HNO_3 (3 : 97), and then filter, wash the residue and titrate as in the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.[1]

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

DETERMINATION OF MANGANESE BY THE PERSULFATE-ARSENITE METHOD.

(ROUTINE AND IN THE PRESENCE OF COBALT.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with constant stirring, into 500 cc. of distilled water.

Dilute Nitric Acid (sp. gr. 1.20).—Mix 380 cc. of HNO_3 (sp. gr. 1.42) and 620 cc. of distilled water.

Silver Nitrate (0.5-per-cent).—Dissolve 5 g. of $AgNO_3$ in a mixture of 750 cc. of distilled water with 250 cc. of H_2SO_4 (1 : 1).

Ammonium Persulfate (15-per-cent).—Prepare as needed by dissolving 15 g. of $(NH_4)_2S_2O_8$ in 100 cc. of distilled water.

Sodium Chloride (0.5-per-cent).—Dissolve 5 g. of NaCl in 1000 cc. of distilled water.

Standard Sodium Arsenite Solution.—Dissolve 2 g. of sodium arsenite in 1000 cc. of distilled water and standardize against a standard steel or by withdrawing 10 cc. of 0.03 *N* permanganate (or its equivalent) into a 250-cc. beaker, adding 50 cc. of water and 10 cc. of H_2SO_4 (1 : 1) and titrating with the arsenite solution.

METHOD.

Transfer 0.50 g. of steel to a flask, add 25 cc. of water, 5 cc. of dilute H_2SO_4 (1 : 1) and 2 cc. of phosphoric acid (85-per-cent) and heat until all effervescence ceases. Add 10 cc. of HNO_3 (sp. gr. 1.20), and boil to dissolve the tungstic acid. Add 50 cc. of silver nitrate solution (0.5-per-cent) (sufficient for 5 per cent chromium steel), boil, and add 15 cc. of ammonium persulfate solution (15-per-cent). Remove the flask from the heat, allow to stand in a warm place until the color has developed, and then rapidly cool. Transfer the solution to a 250-cc. beaker, dilute to a volume of 100 cc. and add 30 cc. of sodium chloride solution (0.5-per-cent) to precipitate the silver. Titrate with the standard sodium arsenite solution to the disappearance of the pink tint of permanganic acid. The addition of sodium chloride is unnecessary if the solution of permanganic acid is quite cold and the titration is conducted rapidly.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

DETERMINATION OF PHOSPHORUS
BY THE
MOLYBDATE-MAGNESIA METHOD.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 1).—Dilute 500 cc. of HCl (sp. gr. 1.19) with 500 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 10).—Dilute 100 cc. of HCl (sp. gr. 1.19) with 1000 cc. of distilled water.

Ferrous Sulfate.—Dissolve 40 g. of ferrous sulfate in 100 cc. of water and acidify with 1 cc. of H_2SO_4 (sp. gr. 1.84).

Ammonium Molybdate.—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

Dilute Nitric Acid for Washing (2 : 100).—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

Dilute Ammonium Hydroxide (1 : 2).—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

Magnesia Mixture.—See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[1]

METHOD.

Treat 2 g. of the sample, in a porcelain dish provided with a cover glass, with 20 cc. of HNO_3 (sp. gr. 1.42) and 60 cc. of HCl (sp. gr. 1.19). Heat gently until the sample is completely decomposed and then evaporate to dryness. Remove the cover glass and bake until the acid is completely expelled. Cool, add 30 cc. of HCl (sp. gr. 1.19), warm until the soluble salts are dissolved and then evaporate to dryness on the sand-bath. Add 30 cc. of dilute HCl (1 : 1) and boil the solution until the soluble salts are dissolved. Dilute to 60 cc.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (**Serial Designation:** A 33 - 22 T), p. 578.

with boiling water, filter from the silica and tungstic acid, and wash the residue with dilute HCl (1 : 10) until free from iron. (See Note.) Evaporate the filtrate to approximately 20 cc., cool, and make ammoniacal. Dissolve the precipitated hydroxides in the exact amount of HNO_3 (sp. gr. 1.42) necessary to effect complete solution and add 5 cc. in excess. The further treatment depends on whether vanadium is absent or present. If vanadium is absent, proceed as in the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method;[1] if vanadium is present, proceed as in the Determination of Phosphorus in Chrome-Vanadium Steel by the Modified Molybdate-Magnesia Method.[2]

NOTE.

The residue of tungstic and silicic acids sometimes contains very small amounts of phosphorus and in accurate analyses it must be treated as follows: Ignite in a platinum crucible, fuse with a little Na_2CO_3 (free from phosphorus) and dissolve the cooled melt in hot water. Acidify the solution slightly with HCl, add a few crystals of $FeCl_3$, and precipitate with NH_4OH in slight excess. Filter, wash with a hot wash-solution containing a little NH_4OH and NH_4Cl, and discard the filtrate. Dissolve the precipitate of ferric hydroxide and ferric phosphate in a small amount of HCl and add to the main filtrate.

DETERMINATION OF PHOSPHORUS

BY THE

ALKALIMETRIC METHOD.

(ROUTINE.)

SOLUTIONS REQUIRED.

Dilute Nitric Acid (1 : 3).—Dilute 250 cc. of HNO_3 (sp. gr. 1.42) with 750 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 1).—Dilute 500 cc. of HCl (sp. gr. 1.19) with 500 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 10).—Dilute 100 cc. of HCl (sp. gr. 1.19) with 1000 cc. of distilled water.

Ferrous Sulfate.—Dissolve 40 g. of ferrous sulfate in 100 cc. of water and acidify with 1 cc. of H_2SO_4 (sp. gr. 1.84).

Ammonium Molybdate.—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[1]

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

[2] See p. 611.

Dilute Nitric Acid for Washing (2 : 100).—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[1]

Potassium Nitrate (1-per-cent).—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[1]

Phenolphthalein Indicator.—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[1]

Standard Sodium Hydroxide.—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[1]

Standard Nitric Acid.—See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[1]

METHOD.

Treat 2 g. of the sample, in a porcelain dish provided with a cover glass, with 50 cc. of dilute HNO_3 (1 : 3), add 10 cc. of HCl (sp. gr. 1.19) and evaporate to dryness. Dissolve the soluble salts in 30 cc. of dilute HCl (1 : 1) by boiling, dilute to 60 cc. with water, filter and wash the residue with dilute HCl (1 : 10). Evaporate the filtrate to approximately 100 cc., make the solution ammoniacal, add just enough HNO_3 (sp. gr. 1.42) to effect complete solution and then add 5 cc. in excess. The further treatment depends on whether vanadium is absent or present. If vanadium is absent, proceed as in the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).[1] If vanadium is present, proceed as in the Determination of Phosphorus in Chrome-Vanadium Steel by the Modified Alkalimetric Method (Routine).[2]

DETERMINATION OF SULFUR
BY THE
GRAVIMETRIC METHOD.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 10).—Dilute 100 cc. of HCl (sp. gr. 1.19) with 1000 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 1).—Dilute 500 cc. of HCl (sp. gr. 1.19) with 500 cc. of distilled water.

Cinchonine.—See the Determination of Tungsten by the Acid Digestion-Cinchonine Method.[3]

Cinchonine Wash Solution.—See the Determination of Tungsten by the Acid Digestion-Cinchonine Method.[3]

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

[2] See p. 613.

[3] See p. 624.

METHOD.

Treat 5 g. of the sample, in a 600-cc. beaker or Erlenmeyer flask, with 75 cc. of HNO_3 (sp. gr. 1.42) and heat gently. Certain steels react violently. In this event, do not heat but cool the vessel in cold water in order to prevent loss of incompletely oxidized sulfur. Some steels dissolve very slowly. In this case add 5 cc. of HCl (sp. gr. 1.19) in successive portions as the solution is digested on a steam-bath. When the steel is dissolved, digest until the residue is bright yellow with no dark material, adding fresh portions of acid if necessary. Evaporate the solution to small volume, cool, add 30 cc. of HCl (sp. gr. 1.19), again evaporate to small volume and dilute with boiling water. Boil until soluble salts are in solution, filter and wash the precipitate with dilute HCl (1 : 10), catching the filtrate and washings in a 600-cc. casserole. Evaporate the solution to dryness, add 40 cc. of HCl (sp. gr. 1.19) and again evaporate to dryness and heat for ten minutes at a temperature not to exceed 130° C. Treat the residue with 60 cc. of dilute HCl (1 : 1), warm until soluble salts are in solution, dilute with 50 cc. of boiling water and add 10 cc. of cinchonine solution. After standing in a warm place for several hours, preferably overnight, filter, and wash with cinchonine wash solution. Evaporate the filtrate and washings until a slight film begins to form upon the surface of the solution and proceed as in the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.[1] The results should be corrected by blanks on reagents carried through all of the steps of the process, paying particular attention to sulfur derived from the cinchonine solution.

DETERMINATION OF SILICON
BY
ACID ATTACK AND BAKING AT 120° C.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 10).—Pour 100 cc. of HCl (sp. gr. 1.19) into 1000 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 1).—Pour 500 cc. of HCl (sp. gr. 1.19) into 500 cc. of distilled water.

Dilute Hydrochloric Acid (5 : 95).—Pour 50 cc. of HCl (sp. gr. 1.19) into 950 cc. of distilled water.

Dilute Sulfuric Acid (1 : 1).—Cautiously pour, with constant stirring, 500 cc. of H_2SO_4 (sp. gr. 1.84) into 500 cc. of distilled water.

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 – 22 T), p. 578.

Sodium Hydroxide (2 N).—Dissolve 80 g. of NaOH in 1000 cc. of distilled water.

METHOD.

Treat 2 g. of the sample in a covered beaker with 50 cc. of HCl (sp. gr. 1.19) heat to incipient boiling and then when solution is complete add HNO_3 (sp. gr. 1.42) at intervals and a few drops at a time until the vigorous action which ensues ceases. Digest until the tungstic acid is bright yellow. Add 100 cc. of boiling water, boil for one minute, cool somewhat and filter. Wash the residue thoroughly with dilute HCl (1 : 10) and set the precipitate aside. Evaporate the filtrate to dryness and bake for one hour at a temperature of 120° C. Take up in 15 cc. of HCl (sp. gr. 1.19) and bake again. Take up in 10 cc. of dilute HCl (1 : 1) and 50 cc. of hot water. Filter and wash with dilute HCl (5 : 95). Reserve the filtrate. Ignite the two residues and filter papers in an open deep-form platinum crucible at a temperature high enough to dehydrate the silica and weigh. Treat the residue with a few drops of dilute H_2SO_4 (1 : 1), a few cubic centimeters of hydrofluoric acid and carefully evaporate to dryness. Ignite very cautiously (to avoid spattering) at a temperature not above 800° C. and weigh. The loss in weight is the weight of silica which multiplied by 0.4676 gives the weight of silicon.

Dissolve the ignited tungstic oxide in a slight excess of NaOH solution (2 *N*), boil, and filter off any residue. Wash the residue with hot water, dissolve it in a few cubic centimeters of hot dilute HCl (1 : 1), add the solution to the reserved filtrate and preserve the combined solutions for the Determination of Cobalt as below.

DETERMINATION OF TUNGSTEN
BY THE
ACID DIGESTION-CINCHONINE METHOD.

SOLUTIONS REQUIRED.

Cinchonine.—Dissolve 125 g. of cinchonine in a mixture of 500 cc. of HCl (sp. gr. 1.19) and 500 cc. of distilled water.

Cinchonine Wash Solution.—Dilute 30 cc. of the above solution to one liter.

Ammonia-Ammonium Chloride.—Pour 200 cc. of NH_4OH (sp. gr. 0.90) into 790 cc. of water and add 10 cc. of HCl (sp. gr. 1.19).

Dilute Hydrochloric Acid (1 : 1).—Pour 500 cc. of HCl (sp. gr. 1.19) into 500 cc. of distilled water.

METHOD.

Treat 2 g. of the sample in a covered beaker with 50 cc. of HCl (sp. gr. 1.19), heat to incipient boiling and then when solution is complete, add HNO_3 (sp. gr. 1.42) at intervals and a few drops at a time until the vigorous action which ensues ceases. Digest until the tungstic acid is bright yellow. Dilute to 150 cc., add 10 cc. of cinchonine solution, and digest at a temperature of about 90 to 95° C. for thirty minutes or longer, with occasional stirring. Decant the clear solution on a paper, and wash the beaker and the precipitate by decantation four times with 30 to 40-cc. portions of the hot cinchonine wash solution, keeping as much of the precipitate as possible in the beaker. Place the beaker and precipitate under the funnel, and dissolve the precipitate on the paper in the least possible amount of the ammonia-ammonium chloride solution. Wash the paper several times with hot water, once with hot dilute HCl (1 : 1), several more times with hot water, and finally with small portions of the ammonia-ammonium chloride wash. Reserve the paper. Warm the filtrate and add just enough NH_4OH (sp. gr. 0.90) to dissolve the tungstic acid. Evaporate the solution until most of the ammonia has been expelled and then filter through the reserved paper into a 400-cc. beaker. Wash the original beaker and the paper with small portions of hot water. Reserve the filtrate. The residue may contain a little tungsten, therefore treat it with successive small portions of hot dilute HCl (1 : 1), hot water, and ammonia-ammonium chloride solution. Render this solution slightly alkaline, boil to expel most of the ammonia, filter through the original paper and wash with a little hot water. Combine the ammoniacal filtrates. (The above treatments serve to remove any tantalum or columbium as well as iron and chromium and render unnecessary any purification of the final hydrofluoric acid-treated tungstic oxide.) Dilute the faintly ammoniacal filtrates to 200 cc., add 10 cc. of HCl (sp. gr. 1.19) and boil for ten minutes. Add 10 cc. of cinchonine solution and digest in a warm place for 15 to 30 minutes with occasional stirring. Add a little paper pulp, filter, and wash the precipitate with hot cinchonine wash solution. Add 5 cc. of cinchonine to the filtrate and washings, set aside in a warm place for several hours, and in case any tungstic acid settles out, filter it off, wash and add to the main precipitate. Ignite the tungstic acid under oxidizing conditions in a deep-form platinum crucible until the carbon is destroyed and finally at 800 to 900° C. Cool the crucible and contents, moisten the oxide with hydrofluoric acid, carefully evaporate to dryness and then cautiously (to avoid spattering) ignite as before and weigh as WO_3. Multiply by 0.7931 to obtain the weight of tungsten.

NOTES.

1. Tungstic acid is incompletely precipitated by acid digestion alone of solutions containing appreciable amounts of alkali or ammonium salts, phosphorus, or molybdenum, and only slowly by cinchonine in such solutions.

2. Tungstic acid carries down phosphorus pentoxide if it is present in appreciable amount. The small amount present in the solution of the steel is not carried down in sufficient amount to affect the determination of tungsten.

3. Molybdenum is carried down by tungstic acid and must be recovered from the final weighed oxide as specified under the Determination of Molybdenum in Molybdenum Steel by Precipitation as Sulfide and weighing as Lead Molybdate ((*b*) Presence of Tungsten)[1] and deducted as MoO_3.

DETERMINATION OF TUNGSTEN AND SILICON
BY
DIGESTION WITH ACIDS.
(ROUTINE.)

METHOD.

(*a*) *Determination of Silicon.*

Proceed exactly as in the Determination of Silicon above until the ignition of the tungstic and silicic acids. Then ignite in a weighed deep-form platinum crucible at a temperature of from 800 to 900° C. and under oxidizing conditions. Weigh, treat the residue with a few drops of dilute H_2SO_4 (1 : 1), and a few cubic centimeters of hydrofluoric acid, and carefully evaporate to dryness. Ignite very cautiously (to avoid spattering) at a temperature not above 800 to 900° C. and again weigh. The loss of weight represents silica which multiplied by 0.4676 gives silicon.

(*b*) *Determination of Tungsten.*

The weight of the residue left after the above treatment represents impure tungstic oxide. To correct for the impurities, cover the residue with about twice its weight of pure dry sodium carbonate and heat until thoroughly fused. Extract the cooled melt with hot water, filter, and wash the residue thoroughly with hot water. Ignite the residue in the original crucible, weigh, subtract the weight from the weight of the crucible and impure tungstic oxide, and multiply the corrected weight of WO_3 by 0.793 to obtain tungsten.

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[1] See p. 636.

DETERMINATION OF CHROMIUM
BY THE
PERSULFATE OXIDATION METHOD.

See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[1]

DETERMINATION OF VANADIUM
BY THE
ELECTROLYTIC SEPARATION METHOD.

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with constant stirring, into 500 cc. of distilled water.

Dilute Sulfuric Acid (1 : 3).—Pour 200 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with constant stirring, into 600 cc. of distilled water.

Sodium Carbonate (8-per-cent) —Dissolve 80 g. of Na_2CO_3 in 1000 cc. of distilled water.

Potassium Ferrocyanide.—See the Determination of Vanadium in Chrome-Vanadium Steel by the Electrolytic Separation Method.[2]

Standard Potassium Permanganate.—See the Determination of Vanadium in Chrome-Vanadium Steel by the Electrolytic Separation Method.[2]

METHOD.

Dissolve 2 g. of the sample, contained in a 200-cc. covered Erlenmeyer flask, in 20 cc. of dilute H_2SO_4 (1 : 1). When action is complete, dilute to 100 cc. with boiling water, heat to boiling, and add sodium carbonate solution (8-per-cent) from a burette until a permanent precipitate appears and then 4 cc. in excess. Let settle, filter on a rapid filter, and quickly wash the flask and precipitate with hot water. (If the precipitation has been properly preformed there will be no more precipitate than can be conveniently handled on a 9-cm. paper. The filtrate will become cloudy in the funnel stem and in the receiving vessel owing to oxidation and hydrolysis.) Place the paper and precipitate in the original flask, add 20 cc. of HNO_3 (sp. gr. 1.42), shake until the paper is broken up, and then add 5 cc. of H_2SO_4 (sp. gr. 1.84). Heat over a free flame until fumes of sulfuric acid are given off, cool, and then add more HNO_3 and repeat the heating in case the organic matter has not been destroyed. Finally cool, wash down the sides of the flask, and evaporate again until fumes of H_2SO_4 appear and until all of the nitric acid has been expelled. Cool, dilute with three times as much water as there is sulfuric acid present, warm to dissolve the soluble salts and filter off the tungstic acid on a small filter. Wash the paper and precipitate with small portions of dilute H_2SO_4 (1 : 3). Nearly neutralize the filtrate with NH_4OH (sp. gr. 0.90), evaporate if necessary to a volume of approximately 70 cc. and proceed with the electrolysis of the weakly acid solution and the determination of vanadium as in the Determination of Vanadium in Chrome-Vanadium Steel by the Electrolytic Separation Method.[1]

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[1] See p. 609.

[2] See p. 615.

DETERMINATION OF VANADIUM

BY

REDUCTION WITH FERROUS SULFATE AND TITRATION WITH PERMANGANATE.

(ROUTINE.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with constant stirring into 500 cc. of distilled water.

Dilute Nitric Acid (sp. gr. 1.20).—Mix 380 cc. of HNO_3 (sp. gr. 1.42) and 620 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 1).—Mix 500 cc. of HCl (sp. gr. 1.19) and 500 cc. distilled water.

Dilute Hydrochloric Acid (1 : 10).—Mix 100 cc. of HCl (sp. gr. 1.19) and 1000 cc. of distilled water.

Ammonium Persulfate (15-per-cent).—See the Determination of Vanadium in Chrome-Vanadium Steel by Reduction with Ferrous Sulfate and Titration with Permanganate Method (Routine).[2]

Ferrous Sulfate.—See the Determination of Vanadium in Chrome-Vanadium Steel by Reduction with Ferrous Sulfate and Titration with Permanganate Method (Routine).[2]

Standard Potassium Permanganate.—See the Determination of Vanadium in Chrome-Vanadium Steel by Reduction with Ferrous Sulfate and Titration with Permanganate Method (Routine).[2]

METHOD.

Dissolve 2 g. of the steel in 20 cc. of dilute H_2SO_4 (1 : 1) and 60 cc. of water. When action ceases, add 10 cc. of dilute HNO_3 (sp. gr. 1.20) and 2 cc. of dilute HCl (1 : 1). Boil the solution for ten minutes, dilute to 50 cc., filter, and wash with a small amount of dilute HCl (1 : 10). To the filtrate add 5 cc. of H_3PO_4 (85-per-cent), and then permanganate solution to the appearance of a permanent pink color. Proceed with the reduction with ferrous sulfate, addition of persulfate and titration with permanganate as in the Determination of Vanadium in Chrome-Vanadium Steel by Reduction with Ferrous Sulfate and Titration with Permanganate Method (Routine).[1]

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[1] See p. 615.

[2] See p. 617.

DETERMINATION OF NICKEL BY THE GRAVIMETRIC DIMETHYLGLYOXIME METHOD.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 10).—Mix 100 cc. of HCl (sp. gr. 1.19) and 1000 cc. of distilled water.

Sodium Hydroxide (2 N).—Dissolve 80 g. of NaOH in 1000 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 1).—Mix 500 cc. of HCl (sp. gr. 1.19) and 500 cc. of distilled water.

Dimethylglyoxime (1-per-cent).—See the Determination of Nickel in Nickel Steel by the Gravimetric Dimethylglyoxime Method.[2]

METHOD.

Treat 2 g. of the sample in a covered beaker with 50 cc. of HCl (sp. gr. 1.19), heat to incipient boiling and then when solution is complete add HNO_3 (sp. gr. 1.42) at intervals and a few drops at a time until the vigorous action which ensues ceases. Digest until the tungstic acid is bright yellow. Add 100 cc. of boiling water, boil for one minute, cool somewhat and filter. Wash the residue thoroughly with dilute HCl (1 : 10) and reserve the filtrate. Dissolve the tungstic acid in a slight excess of sodium hydroxide solution (2 *N*), boil and filter off any residue. Wash the residue with hot water, discard the filtrate and dissolve the residue in a few cubic centimeters of hot dilute HCl (1 : 1), add the solution to the main reserved filtrate and proceed with the determination of nickel as in the Determination of Nickel in Nickel Steel by the Gravimetric Dimethylglyoxime Method.[2]

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[1] See p. 617.

[2] See p. 601.

NOTES.

It is difficult to precipitate nickel and to obtain it free from cobalt when cobalt is preponderant. Complete precipitation may be obtained by adding sufficient dimethylglyoxime to react with both cobalt and nickel and digesting for a longer period, or, by oxidizing the cobalt to the trivalent condition by means of $NaClO_3$ or $(NH_4)_2S_2O_8$ in ammoniacal solution before precipitating with dimethylglyoxime. In either case, the first precipitate should be filtered off, dissolved, and reprecipitated.

Direct weighing of nickel dimethylglyoxime is desirable when small amounts of nickel are concerned. Large precipitates are more conveniently ignited at red heat to NiO. In this case, care must be taken to prevent sublimation of the undecomposed salt. This may be accomplished by enclosing the wet paper and precipitate in one or two wet ashless papers and slowly igniting so that the papers char before taking fire. In this way the compound is decomposed and ignition may proceed at full red heat.

DETERMINATION OF NICKEL
BY THE
CYANIDE TITRATION METHOD.
(ROUTINE.)

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (*1 : 10*).—Mix 100 cc. of HCl (sp. gr. 1.19) and 1000 cc. of distilled water.

METHOD.

Treat 2 g. of the sample in a covered beaker with 50 cc. of HCl (sp. gr. 1.19), heat to incipient boiling and then when solution is complete add HNO_3 (sp. gr. 1.42) at intervals and a few drops at a time until the vigorous action which ensues ceases. Digest until the tungstic acid is bright yellow. Add 100 cc. of boiling water, boil for one minute, cool somewhat and filter. Wash the residue thoroughly with dilute HCl (1 : 10) and determine nickel in the filtrate as in the Determination of Nickel in Nickel Steel by the Cyanide Titration Method.[1]

NOTE.

In case cobalt is present, the preliminary separation (*a*) as given in the cyanide titration method must be employed.

DETERMINATION OF COBALT.

SOLUTIONS REQUIRED.

Sodium Carbonate (*10-per-cent*).—Dissolve 100 g. of Na_2CO_3 in 1000 cc. of distilled water.

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[1] See p. 603.

Ammonium Acetate (5-per-cent).—Dissolve 50 g. of $NH_4C_2H_3O_2$ in 1000 cc. of distilled water.

Dilute HCl (1 : 1).—Mix 500 cc. of HCl (sp. gr. 1.19) and 500 cc. of distilled water.

Acidulated Hydrogen Sulfide Water.—Mix 20 cc. of H_2SO_4 (sp. gr. 1.84) and 1000 cc. of distilled water, cool, and saturate with H_2S.

Nitroso Beta Naphthol (7-per-cent).—Prepare as needed by dissolving in the proportion of 7 g. of the compound to 100 cc. of glacial acetic acid.

METHOD.

See the Determination of Silicon by the Acid Attack and Baking at 120° C. Method.[1]

Employ the HCl solution reserved in this determination or prepare a similar solution by treatment of a new 1-g. sample in the same fashion, with the difference, however, that the wet tungstic acid is not ignited but treated directly with NaOH solution (2 *N*) for the recovery of its cobalt content.

Evaporate the HCl solution to a volume of approximately 100 cc. and neutralize the acid solution by adding solid Na_2CO_3 until the acid is nearly destroyed and then continuing with care by adding sodium carbonate solution (10-per-cent), drop by drop with vigorous stirring, until the solution has become amber colored and the precipitate dissolves with difficulty. Pour the feebly acid solution slowly and with constant stirring into 200 cc. of boiling ammonium acetate solution (5-per-cent). Boil for two to three minutes, allow to settle, filter without washing on a large rapid filter and reserve the filtrate which must be absolutely clear. Dissolve the precipitate in as little hot dilute HCl (1 : 1) as possible, catching the solution in the unwashed beaker and reprecipitate as before, taking the same precautions as to preliminary neutralization and the volumes employed. Again filter without washing, discard the precipitate and combine the filtrate with that already reserved. The combined filtrates should now be free from iron, chromium and vanadium but may contain such elements as molybdenum, copper and small amounts of tungsten in addition to cobalt, nickel and manganese. To eliminate molybdenum and tungsten and to concentrate the others, neutralize the combined solutions with NH_4OH (sp. gr. 0.90) add 30 cc. in excess, and saturate the solution with a rapid current of H_2S. Allow the precipitate to settle, filter without washing, discard the clear filtrate, and transfer the paper and precipitate to a 250-cc. Erlenmeyer flask. Dissolve any precipitate adhering to the precipitation beaker in 20 cc. of HNO_3 (sp. gr. 1.42) and a little HCl (sp. gr. 1.19), pour the solution on the paper and precipitate and shake until the paper has disintegrated. Add 5 cc. of H_2SO_4 (sp. gr. 1.84) and heat over a free flame until fumes of H_2SO_4 are evolved. In case the organic matter has not been destroyed add a little more HNO_3 and repeat the HNO_3 treatment and the evaporation until fumes of H_2SO_4 appear. Cool, dilute to 100 cc., add 2 cc. of NH_4OH (sp. gr. 0.90) and saturate the acid solution with a rapid current of H_2S. Filter, wash with acidulated H_2S water and discard the precipitate. Boil the filtrate until H_2S has been expelled, and the solution reduced to a volume of 100 cc. and then proceed as in (*a*) or (*b*) below.

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[1] See p. 623.

(*a*) *Determination of Cobalt by the Electrolytic Method.*

Add 5 cc. of H_2SO_4 (sp. gr. 1.84), neutralize with NH_4OH (sp. gr. 0.90), add 35 cc. in excess and then 2 g. of $NaHSO_3$. Electrolyze in a volume of 150 cc. for 6 hours or overnight, using gauze electrodes and a current density of 0.2 to 0.3 ampere per dm^2. Wash the cathode with cold water, dry at 100° C., and weigh the deposit. The electrolyte usually contains from 0.1 to 1 mg. of nickel and cobalt (mainly cobalt) and should be tested as follows: Boil the electrolyte with an excess of ammonium persulfate, keeping the solution strongly ammoniacal, to precipitate manganese. Filter, wash, and discard the precipitate and saturate the clear ammoniacal filtrate with H_2S. Digest at the side of the steam-bath for 1 hour, filter if a precipitate has appeared, and wash with water containing a little NH_4Cl and $(NH_4)_2S$. Ignite, weigh the combined oxides of nickel and cobalt, multiply by the empirical factor 0.75 and add to the cathode weight. The weight of cobalt must then be found by deducting nickel as determined on a separate portion of the steel or by analysis of the deposit and the small recovery from the electrolyte. In either case, attention must be paid to the difficulty in precipitating small amounts of nickel as pure nickel dimethylglyoxime in the presence of large amounts of cobalt, as described under the Determination of Nickel in Nickel Steel by the Gravimetric Dimethylglyoxime Method.[1]

NOTE.

Tungsten, molybdenum and vanadium must be completely removed in order to obtain a satisfactory deposition of nickel and cobalt.

(*b*) *Determination of Cobalt by the Nitroso-Beta-Naphthol Method.*

Transfer the solution to a 600-cc. beaker, add NH_4OH (sp. gr. 0.90) until the solution is slightly ammoniacal and then HCl (sp. gr.

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[1] See p. 601.

1.19) until in 5 cc. excess. Dilute to 350 cc., heat to boiling, and for each centigram of cobalt expected add, with constant stirring, 6 cc. of nitroso-beta-naphthol solution (7-per-cent). Set aside until the precipitate has settled, filter on paper, and wash the precipitate twice, alternately with dilute HCl (1 : 1) and water, and finally with hot water. Transfer to a porcelain crucible, heat gently until the carbonaceous matter has been destroyed, and then at a high temperature for 20 minutes. Cool in a desiccator and weigh as Co_3O_4.

NOTES.

The ignited oxide does not have the exact formula Co_3O_4 and therefore in case the weight is appreciable it is safer to change the oxide to metallic cobalt by repeated ignition in hydrogen in a Rose-form crucible until the weight is constant.

The precipitate is apt to be contaminated by nickel in case nickel is preponderant in the original solution.

DETERMINATION OF COBALT
BY
CYANIDE TITRATION.
(ROUTINE.)

SOLUTIONS REQUIRED.

Sulfuric-Citric Acid.—Dissolve 200 g. of citric acid in a cooled mixture of 100 cc. of H_2SO_4 (sp. gr. 1.84) and 900 cc. of distilled water.

Dilute Nitric Acid (1 : 3).—Mix 200 cc. of HNO_3 (sp. gr. 1.42) and 600 cc. of distilled water.

Potassium Iodide (10-per-cent).—See the Determination of Nickel in Nickel Steel by the Cyanide Titration Method.[1]

Standard Silver Nitrate.—See the Determination of Nickel in Nickel Steel by the Cyanide Titration Method.[1]

Standard Potassium Cyanide.—See the Determination of Nickel in Nickel Steel by the Cyanide Titration Method.[1]

METHOD.

See the Determination of Silicon by the Acid Attack and Baking at 120° C. Method.[2]

To the reserved HCl solution or one prepared in the same way from a new portion of steel, add 50 cc. of the sulfuric-citric acid solution and then NH_4OH (sp. gr. 0.90) until in 10 to 15 cc. excess. Bring the solution to boiling , add 1 g. of $NaClO_3$, and boil for 5 minutes. Cool, dilute to 200 cc., add dilute HNO_3 (1 : 3), carefully, until the solution is just neutral and then add 5 cc. of NH_4OH (sp. gr. 0.90).

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[1] See p. 603.

[2] See p. 623.

Again cool if necessary, add 2 cc. of potassium iodide solution (10-percent) and titrate as in the Determination of Nickel in Nickel Steel by the Cyanide Titration Method.[1] The volume of standard cyanide solution which is actually consumed represents the sum of nickel and cobalt. The volume of standard cyanide solution consumed by the nickel may be found and deducted by a determination of nickel as in the Determination of Nickel in Tungsten Steel by the Cyanide Titration Method (Routine) with preliminary separation (*a*)[2] or by calculation based on a determination of nickel as in the Determination of Nickel in Tungsten Steel by the Gravimetric Dimethylglyoxime Method.[3] In either case, the volume of standard cyanide solution consumed by cobalt represents that required to convert cobalt to the compound $K_2Co(CN)_5$ and the cobalt titre of the cyanide solution is best found by titration of material of known cobalt content under the conditions that obtain in the method.

DETERMINATION OF COPPER.

In steels containing little tungsten, proceed as in the Determination of Copper in Plain Carbon Steel.[4]

In steels containing considerable tungsten, proceed as in the Determination of Copper in Plain Carbon Steel[4] with the single exception that the first sulfide precipitate and paper is digested with HNO_3 and H_2SO_4 to complete destruction of organic matter instead of igniting the paper and residue. The H_2SO_4 solution is then cooled, diluted, boiled with an excess of NaOH solution (2 *N*) and treated as in the ordinary procedure.

MOLYBDENUM STEEL.

DETERMINATION OF CARBON.

See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.[4]

DETERMINATION OF MANGANESE.

(*a*) *Determination of Manganese* (Absence of Chromium and Cobalt).

See the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.[4]

(*b*) *Determination of Manganese* (Presence of Chromium and Absence of Cobalt).

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[1] See p. 603.

[2] See p. 630.

[3] See p. 629.

[4] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T), p. 578.

See the Determination of Manganese in Chrome-Nickel Steel by the Hydrolysis-Bismuthate Method.[1]

(*c*) *Determination of Manganese* (Routine and in Presence of Cobalt).

See the Determination of Manganese in Plain Carbon Steel by the Persulfate Method.[2]

DETERMINATION OF PHOSPHORUS.

(*a*) *Determination of Phosphorus* (Absence of Vanadium).

See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.[2]

(*b*) *Determination of Phosphorus* (Presence of Vanadium).

See the Determination of Phosphorus in Chrome-Vanadium Steel by the Modified Molybdate-Magnesia Method.[3]

(*c*) *Determination of Phosphorus* (Routine and in Presence of Vanadium).

See the Determination of Phosphorus in Chrome-Vanadium Steel by the Modified Alkalimetric Method (Routine).[4]

(*d*) *Determination of Phosphorus* (Routine in Absence of Vanadium).

See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method.[2]

DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.[2]

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).[2]

NOTES.

The ordinary evolution method yields low values with molybdenum steel. Good results are obtained on annealed samples with HCl (sp. gr. 1.19).

DETERMINATION OF SILICON.

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.[2]

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric Acid Method (Optional).[2]

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[1] See p. 606.

[2] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 – 22 T), p. 578.

[3] See p. 611.

[4] See p. 613.

DETERMINATION OF MOLYBDENUM BY PRECIPITATION AS SULFIDE AND WEIGHING AS LEAD MOLYBDATE.

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) slowly and with stirring into 500 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 1).—Pour 500 cc. of HCl (sp. gr. 1.19) into 500 cc. of distilled water.

Dilute Hydrochloric Acid (1 : 9).—Pour 100 cc. of HCl (sp. gr. 1.19) into 900 cc. of distilled water.

Bromine Water.—A saturated solution.

Ammonium Persulfate (10-per-cent).—Prepare as needed by dissolving 1 g. of the persulfate in 10 cc. of distilled water.

Acidulated Hydrogen Sulfide Water.—Pour 10 cc. of sulfuric acid (sp. gr. 1.84) into 1000 cc. of distilled water. Add 10 g. of tartaric acid and saturate the solution with H_2S.

Sodium Hydroxide (2 N).—Dissolve 80 g. of NaOH in 1000 cc. of distilled water.

Ammonium Acetate (50-per-cent).—Dissolve 100 g. of ammonium acetate in 100 cc. of distilled water.

Lead Acetate (1-per-cent).—Dissolve 10 g. of lead acetate in a mixture of 990 cc. of distilled water and 10 cc. of acetic acid. Filter if necessary.

Ammonium Nitrate (2.5-per-cent).—Dissolve 25 g. of NH_4NO_3 in 1000 cc. of distilled water, filter if necessary, and make sure that the solution is neutral.

METHOD.

(*a*) *Determination of Molybdenum* (Absence of Tungsten).

In an 800-cc. beaker, dissolve a sufficient amount of the sample to yield approximately 0.03 g. of molybdenum in a mixture of 100 cc. of water and 50 cc. of H_2SO_4 (1 : 1). When effervescence ceases, add 10 cc. of ammonium persulfate solution (10-per-cent), boil to oxidize molybdenum and part of the iron and cool somewhat. (Note 1.) Add 5 g. of tartaric acid (Note 2) nearly neutralize with NH_4OH (sp. gr. 0.90) heat nearly to boiling and pass in H_2S *rapidly* for ten minutes or until the iron has been reduced and the molybdenum precipitated. Allow the solution to stand on the steam-bath at 50 to 60° C. for three hours, filter and wash the sulfur and sulfides with acidulated hydrogen sulfide water. Treat the sulfides as below. Boil the filtrate to expel hydrogen sulfide, and until the volume is reduced to from 400 to 500 cc. Add 10 cc. of ammonium persulfate solution (10-per-cent), boil, and again precipitate with H_2S as above in order to recover any molybdenum which escaped the first precipitation. Wash the main precipitate and the recovered precipitate from the papers into a 400-cc. beaker and dissolve the part remaining on the papers in 20 cc. of hot dilute HCl (1 : 1) and bromine water, the solution being received in the 400-cc. beaker. Finally wash the papers with a little water and ignite them with the paper reserved below. Dilute the solution to 100 cc., add 20 cc. of HCl (sp. gr. 1.19) and 3 g. of sodium chlorate and boil until the molybdenum sulfide is dissolved. Filter, wash the paper and residue with water, and reserve the filtrate. Ignite the papers and residues at a very low temperature in a deep-form crucible (to avoid volatilization loss of any MoO_3), treat any resdue with warm NaOH solution (2 *N*) and pour the solution into the main filtrate. Nearly neutralize the combined solutions with sodium hydroxide solution (2 *N*) and pour the clear *yellow* solution slowly and with stirring into 100 cc. of boiling sodium hydroxide solution (2 *N*) contained in a 400-cc. beaker. After the precipitate has settled, filter and wash thoroughly with hot water. Reserve the filtrate and dissolve the precipitate in hot dilute HCl (1 : 1) and re-precipitate with sodium hydroxide solution (2 *N*) as above (Note 3). Neutralize the combined filtrates with HCl (sp. gr. 1.19) add 5 cc. in excess and evaporate the solution to 250 cc. To the clear solution add 50 cc. of ammonium acetate solution (50-per-cent), heat to boiling and slowly add lead acetate solution (1-per-cent) from a burette dropwise and with continual stirring, until in slight excess. This is usually shown by a clearing of the solution. At this point discontinue the addition of the acetate, boil the solution for two or three minutes while stirring, allow the precipitate to settle somewhat, and test the supernatant liquid with a few drops more of the acetate. When precipitation is complete, boil for ten minutes, allow to settle and filter the supernatant liquid through an ashless filter. Wash 3 or 4 times by decantation with 75-cc. portions of hot ammonium nitrate solution (2.5-per-cent), and finally transfer and complete the washing of the precipitate on the paper. If the precipitate is large or much sulfate was present in the solution, it is advisable to dissolve the first precipitate in hot dilute HCl (1 : 1) and re-precipitate it as above in order to avoid undue contamination by lead sulfate or sodium salts. The precipitate may be carefully ignited directly in a porcelain crucible under oxidizing conditions until the carbon is destroyed or else the paper and precipitate may be dried at 100° C., the precipitate removed from the paper, and the paper carefully ignited separately before the ignition of the main precipitate. In either case the final ignition to $PbMoO_4$ should be at a very dull red heat (Note 4).

(*b*) *Determination of Molybdenum* (Presence of Tungsten).

Treat the sample, in a 400-cc. beaker, with 50 cc. of dilute HCl (1 : 1), and when solution is complete add 10 cc. of HNO_3 (sp. gr. 1.42) to oxidize the iron and the tungsten. Digest until the tungstic acid is bright yellow, filter and wash with dilute HCl (1 : 9). Reserve the precipitate. Add 30 cc. of dilute H_2SO_4 (1 : 1) to the filtrate, evaporate until fumes of H_2SO_4 appear, cool and add 40 cc. of water. If a light residue of tungstic acid separates, filter it off on a small filter, wash with a little dilute sulfuric acid, and treat it together with the main tungstic acid precipitate. Add 3 g. of tartaric acid to the clear solution, nearly neutralize with NH_4OH (sp. gr. 0.90), precipitate the molybdenum as sulfide in slightly acid solution and proceed as above. In order to recover the molybdenum which is always carried down by tungstic acid, dissolve the tungstic acid residues by pouring hot sodium hydroxide solution (2 *N*) upon them and finally wash the papers with a little hot dilute sulfuric acid. To the filtrate add 5 g. of tartaric acid, make slightly acid with sulfuric acid, and precipitate as above with hydrogen sulfide. Any molybdenum recovered here is apt to be contaminated by tungsten and therefore the precipitate must be dissolved in a little HCl and bromine water as above, treated with 2 cc. of H_2SO_4 (sp. gr. 1.84) evaporated until fumes of H_2SO_4 appear, cooled and diluted with 6 cc. of water. After warm digestion, filter off the dissolved molybdenum, wash with water containing a little H_2SO_4, add the solution to the reserved major portion, and proceed as in method (*a*).

NOTES.

1. Molybdenum is very slowly and incompletely precipitated by H_2S when in a reduced state.

2. Tartaric acid is necessary to prevent the partial precipitation of vanadium and tungsten by H_2S. These are the main interfering elements in any method for the determination of molybdenum.

3. The two sodium hydroxide precipitations are necessary to completely separate molybdenum from iron which would otherwise be precipitated upon boiling in dilute acetic acid solution.

4. $PbMoO_4$ is somewhat soluble in ammonium acetate solution, but this reagent is necessary to prevent contamination by $PbSO_4$. If the solution contained no sulfates, a more desirable method would consist in precipitating the molybdate in a hot, very dilute HNO_3 solution by means of $Pb(NO_3)_2$, and then, when the precipitate became granular, making the solution faintly alkaline with ammonia and faintly acid with acetic acid.

5. Molybdenum may also be satisfactorily determined by carefully igniting the sulfide to the oxide MoO_3, weighing, and then correcting for iron and copper oxides or, by dissolving the sulfide in acid, freeing the solution from copper, arsenic, and iron, reducing in a Jones' reductor containing ferric alum and phosphoric acid in the receiver, and titrating the reduced oxide (Mo_2O_3) to MoO_3 by means of a standard permanganate solution.

DETERMINATION OF MOLYBDENUM
BY
SODIUM HYDROXIDE SEPARATION, LEAD MOLYBDATE PRECIPITATION.

(ROUTINE.)

SOLUTIONS REQUIRED.

Sodium Hydroxide (2 N).—See the Determination of Molybdenum by Precipitation as Sulfide and Weighing as Lead Molybdate.[1]

Ammonium Acetate (50-per-cent).—See the Determination of Molybdenum by Precipitation as Sulfide and Weighing as Lead Molybdate.[1]

Lead Acetate (1-per-cent).—See the Determination of Molybdenum by Precipitation as Sulfide and Weighing as Lead Molybdate.[1]

Dilute Hydrochloric Acid (1 : 4).—Pour 200 cc. of HCl (sp. gr. 1.19) into 800 cc. of distilled water.

Dilute Hydrochloric Acid (5 : 100).—Pour 50 cc. of HCl (sp. gr. 1.19) into 1000 cc. of distilled water.

METHOD.

(a) *Determination of Molybdenum by Sodium Hydroxide Separation, Lead Molybdate Precipitation* (Absence of Tungsten and Vanadium).

Dissolve 2 g. of the sample in 20 cc. of HCl (sp. gr. 1.19), oxidize with 5 cc. of HNO_3 (sp. gr. 1.42) and expel oxides of nitrogen. Add sodium hydroxide solution (2 *N*) until the excess of free acid is neutralized, taking care not to produce a red solution (dissolved hydrate) or a precipitate (basic molybdate). Heat the solution to boiling, and run the solution of the steel in rapid drops from a tap funnel into 160 cc. of sodium hydroxide solution (2 *N*) with constant stirring of the mixture. Dilute the alkaline solution to exactly 500 cc., filter through a dry filter, discard the first few cubic centimeters, and then take exactly 250 cc. of the filtrate. Neutralize the solution with HCl (sp. gr. 1.19) add 5 cc. in excess, boil, add 20 cc. of ammonium acetate solution (50-per-cent), and proceed as in the Determination of Molybdenum by Precipitation as Sulfide and Weighing as Lead Molybdate,[1] omitting, however, a second precipitation of the lead molybdate.

NOTES.

The above process is of fairly general application. Manganese, nickel, cobalt, aluminum, and the ordinary elements of steel are without influence in the method.

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[1] See p. 636.

Chromium may be partially oxidized to chromate in the alkali treatment but can be reduced to the harmless trivalent condition by adding a few drops of sulfurous acid to the acid solution, prior to the molybdate precipitation. Tungsten and vanadium interfere. Vanadium is not easily removed but the interference of tungsten can be largely overcome by the modification of the method indicated in method (*b*).

(*b*) *Determination of Molybdenum by Sodium Hydroxide Separation, Lead Molybdate Precipitation* (Presence of Tungsten and Absence of Vanadium).

Dissolve 2 g. of the sample in a covered beaker in 50 cc. of HCl (sp. gr. 1.19), heat to incipient boiling and digest on a hot-plate at moderate heat. Add a few drops of HNO_3 (sp. gr. 1.42), wait until the vigorous action ceases, and continue the dropwise addition of the acid until the vigorous action ceases. If this is carefully done, no tungstic acid separates at this stage. Next evaporate the liquid as quickly as possible until tungstic acid begins to separate, and then more slowly until the solution is pasty. Now add 50 cc. of dilute HCl (1 : 4), boil, and set aside for at least 15 minutes. Filter through paper pulp, wash with dilute HCl (5 : 100) and treat the hydrochloric acid solution for molybdenum as above.

DETERMINATION OF MOLYBDENUM
BY THE
COLORIMETRIC METHOD.

(OPTIONAL ROUTINE.)

(ABSENCE OF TUNGSTEN AND HIGH VANADIUM OR COPPER.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 7).—Carefully mix 100 cc. of H_2SO_4 (sp. gr. 1.84) and 700 cc. of distilled water.

Dilute Nitric-Sulfuric Acid Mixture.—Mix 833 cc. of HNO_3 (sp. gr. 1.20) and 167 cc. of H_2SO_4 (1 : 1).

Sulfuric-Hydrochloric Acid Mixture.—Mix 450 cc. of H_2SO_4 (1 : 1), 100 cc. of HCl (1 : 1), and 450 cc. of distilled water.

Ferric Sulfate.—Dissolve 70 g. of ferric sulfate in a mixture of 120 cc. of HCl (1 : 1), 500 cc. of H_2SO_4 (1 : 1), and 380 cc. of distilled water. Filter if necessary.

Chromic Sulfate.—Dissolve 50 g. of chromic potassium sulfate in 100 cc. of H_2SO_4 (1 : 1), and 200 cc. of water and heat until the purple color changes to green. Dilute to 1000 cc.

Stannous Chloride.—Dissolve 250 g. of stannous chloride in 200 cc. of HCl (sp. gr. 1.19), and dilute to 1000 cc. with distilled water.

Standard Molybdenum Solution.—Weigh accurately such an amount of a standard ferro-molybdenum (preferably over 50 per cent molybdenum) as will represent exactly 0.5 g. of molybdenum, and transfer the sample to a platinum dish. Add 20 cc. of dilute HNO_3 (1 : 1), and a few cubic centimeters of hydrofluoric acid, warm until the alloy is dissolved and then add 20 cc. of H_2SO_4 (1 : 1) and evaporate until fumes of H_2SO_4 appear. Cool, add 50 cc. of water, boil until all salts are dissolved and then cool and transfer to a liter flask. Add 100 cc. of H_2SO_4 (1 : 1) and dilute the solution to the mark.

Potassium Thiocyanate (5-per-cent).—Dissolve 50 g. of KCNS in 1000 cc. of distilled water.

METHOD.

Transfer 0.5 g. of the steel to a 200-cc. casserole, dissolve in 10 cc. of the nitric-sulfuric mixture, and then evaporate until fumes of H_2SO_4 are evolved. Cool, add 30 cc. of sulfuric-hydrochloric mixture and heat until the salts are in solution. Cool the solution, transfer to a comparison bath and place in a bath for further cooling. To another comparison tube add 25 cc. of the ferric sulfate solution (0.5 g. Fe), 1 cc. of the chromic sulfate solution for each per cent of chromium present, and then 1 cc. of the standard molybdenum solution for each 0.1 per cent of molybdenum expected. Cool both tubes to the same temperature and add to each from a burette 5 cc. of potassium thiocyanate solution (5-per-cent). Mix the solution in each tube, add 10 cc. of the stannous chloride solution to each from a burette and well mix each solution for 10 seconds. With dilute H_2SO_4 (1 : 7), dilute the standard to some multiple of its molybdenum content and dilute the test until the colors match. The amounts of molybdenum are then directly proportional to the heights of the columns of liquids.

NOTES.

The above method is applicable to steels containing up to 0.5 per cent of molybdenum. Above this percentage the solution of the steel must be divided into aliquot portions and the iron and the hydrochloric acid in the standard varied accordingly.

If the analyst is dealing with steels of approximately the same composition, the iron, chromium (nickel) and molybdenum may be combined so that a single 25-cc. portion is used as the standard.

The amount of hydrochloric acid must be regulated and be the same in the tests as excessive hydrochloric acid causes a fading of the color.

If the steel contains chromium in excess of 1 per cent, difficulty may be encountered in obtaining complete solution after the evaporation to the appearance of fumes of H_2SO_4. In this event, dissolve 0.5 g. of the steel, contained in a 200-cc. flask, in 15 cc. of dilute H_2SO_4 (1 : 1), and 30 cc. of distilled water. When solution is complete, add 15 cc. of $(NH_4)_2S_2O_8$ solution (15-per-cent) and boil, add 3 cc. of dilute HCl (1 : 1), boil 10 minutes to expel the excess of persulfate, and to reduce the volume to 30 cc. preliminary to comparison. If any residue remains, add paper pulp, filter, reserve the filtrate, and transfer the paper and pulp to a 150-cc. beaker and add 10 cc. of HNO_3 (sp. gr. 1.42), 5 g. of sodium chlorate and 5 cc. of H_2SO_4 (sp. gr. 1.84). Evaporate to the appearance of copious fumes and repeat the treatment if the solution is not free from color due to organic matter. Cool and add to the reserved filtrate.

DETERMINATION OF COPPER.

See the Determination of Copper in Plain Carbon Steel.[1]

DETERMINATION OF NICKEL.

See the Determination of Nickel in Nickel Steel by the Gravimetric Dimethylglyoxime Method.[2]

See the Determination of Nickel in Nickel Steel by the Cyanide Titration Method (Routine).[3]

DETERMINATION OF CHROMIUM.

See the Determination of Chromium in Chrome-Nickel Steel by the Persulfate Oxidation Method.[4]

DETERMINATION OF VANADIUM.

See the Determination of Vanadium in Chrome-Vanadium Steel by the Electrolytic Separation Method.[5]

See the Determination of Vanadium in Chrome-Vanadium Steel by Reduction with Ferrous Sulfate and Titration with Permanganate Method (Routine).[6]

DETERMINATION OF TUNGSTEN.

See the Determination of Tungsten in Tungsten Steel by the Acid Digestion-Cinchonine Method.[7]

See the Determination of Tungsten in Tungsten Steel by the Digestion with Acids Method (Routine).[8]

DETERMINATION OF COBALT.

See the Determination of Cobalt in Tungsten Steel by the Sulfide Method.[9]

See the Determination of Cobalt in Tungsten Steel by the Cyanide Titration Method (Routine).[10]

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[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 – 22 T), p. 578.

[2] See p. 601. [3] See p. 603. [4] See p. 609. [5] See p. 615. [6] See p. 617.

[7] See p. 624. [8] See p. 626. [9] See p. 630. [10] See p. 633.

TENTATIVE RECOMMENDED PRACTICE
FOR
HEAT TREATMENT OF CARBON-STEEL CASTINGS.[1]

Serial Designation: A 36 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope. 1. This recommended practice is intended solely for guidance and is not to be construed as entering in any manner into specifications of the American Society for Testing Materials.

Cleaning. 2. The castings should be sufficiently cleaned of adhering sand before annealing to insure thorough and uniform heating. It is, of course, inadvisable to sand blast the castings before annealing.

Annealing and Quenching Temperatures. 3. The castings should be heated slowly and uniformly to temperatures varying with the carbon content of the steel, approximately as follows:

CARBON, PER CENT.	TEMPERATURE.
Up to 0.40	900° C. (1652° F.)
0.40 to 0.60	850° C. (1560° F.)
Above 0.60	830° C. (1525° F.)

Time of Heating. 4. The castings should be kept at the maximum temperature a sufficient length of time to insure the refining of the grain. Generally, from one to two hours is required to accomplish this refining after the steel has reached the maximum temperature. As it requires a considerable length of time for the interior of a heavy piece to reach the indicated temperature of the furnace, it is recommended that the castings be held at the maximum temperature at least forty-five minutes for each inch of thickness of the castings and that to the time estimated from one to two hours be added to insure thorough grain refining throughout the piece.

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[1] This recommended practice, when adopted as standard, will supersede the present Recommended Practice for Annealing of Carbon-Steel Castings (Serial Designation: A 36 - 14), 1921 Book of A.S.T.M. Standards.

Criticisms of this recommended practice are solicited and should be directed, preferably before January 1, 1923, to Mr. J. H. Hall, Secretary of Commitee A-4 on Heat Treatment of Iron and Steel, Taylor-Wharton Iron and Steel Co., High Bridge, N. J.

Slow Cooling. 5. The castings should be cooled slowly and uniformly in the furnace, when it is desired that the steel shall possess the maximum softness. In the case of very heavy castings of comparatively uniform section they may be cooled in the air.

NOTE.—It is, of course, quite unnecessary and superfluous to use this method as preliminary to any of the methods outlined in Sections 6, 7 and 8.

Accelerated Cooling. 6. The castings may be cooled at an accelerated rate when it is desired that the steel possess rather higher tensile strength and elastic limit than can be procured by slow cooling. The cooling must be so conducted as to leave the steel reasonably free from cooling stresses. The castings may be withdrawn from the furnace and buried in a bed of material that is a poor conductor of heat; or the annealing furnace may be so thrown open that the castings will cool more rapidly than they would if the furnace were left closed. Should, however, the castings be of such uneven section that they cool at unequal rates at various points when the furnace is opened, especially if the carbon of the steel is high, the furnace should be closed immediately after the castings have become black, and their further cooling so retarded that the stresses set up by the unequal rates of cooling are relieved.

Rapid Cooling. 7. (*a*) If the sections of the castings are such that the castings will cool in air from the annealing temperature to a black heat in less than 30 minutes, the castings may be withdrawn from the furnace and cooled in the air. When a car-type furnace is used, this may be accomplished by withdrawing the car from the furnace and allowing the casting to remain on the car. In this case, however, care should be taken in loading the car so that the castings will cool as uniformly as possible.

(*b*) When the greatest possible strength and elastic limit for any given extension and contraction are desired, the castings may be quenched in oil or water followed by reheating, provided they are of suitable design and section.

(*c*) Certain castings which would crack if held in the water or oil until completely cold, may be safely treated by removing them from the bath when they have reached a black heat, placing them in a furnace at approximately the same temperature as the castings and immediately reheating them as described in Section 8.

Drawing. 8. Castings which have been cooled in air as described in Section 7 (*a*), or quenched in water or oil as described in Sections 7 (*b*) and 7 (*c*), should be reheated to a temperature not exceeding 675° C. (1247° F.). If there is danger of cracking the castings in this reheating on account of the stresses set up by previous rapid cooling, this second heating should be at a slower rate than the first heating. In no case should the rate for the second heating exceed that for the first heating. The castings should be held at the given temperature at least one hour for each inch of section to insure thorough and uniform heating throughout the piece. To this time of exposure to the maximum temperature should be added at least two hours to complete the drawing of the interior of the castings. After the drawing is completed the castings may be cooled as desired either in the furnace or in the air.

General. 9. In general the shock toughness of the steel is considerably improved and the elastic limit considerably raised by air cooling and drawing as compared with these properties in a similar steel when annealed as described in Section 5. Both these properties are still further improved by quenching and drawing, as described in Sections 7 (*b*) and 8.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM INGOTS FOR REMELTING AND FOR ROLLING.[1]

Serial Designation: B 24 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1918; REVISED, 1919, 1920, 1922.

Material Covered.

1. These specifications cover three grades of Virgin Aluminum, as follows:

GRADE.	ALUMINUM, PER CENT.
99.5	99.5 (Minimum)
99.0	99.0 (Minimum)
98.0	98.0 (Minimum)

Impurities.

2. The presence in any of the above grades of manganese, magnesium, zinc, calcium or similar metals commonly used in the light alloys, is not admissible and such ingot cannot be classed as Virgin Aluminum under these specifications. Copper is an allowable impurity up to a maximum of 0.1 per cent in the 99.5 grade; 0.25 per cent in the 99.0 grade; and 0.45 per cent in the 98.0 grade. Iron and silicon are also allowable impurities. The sum total of the impurities, however, shall not exceed 0.5 per cent in the 99.5 grade, 1.0 per cent in the 99.0 grade, nor 2.0 per cent in the 98.0 grade.

I. MANUFACTURE.

Manufacture.

3. No scrap shall be used other than that resulting in the manufacturer's own plant from the production of material complying with these specifications, and which is of similar composition to the material specified.

II. PHYSICAL DEFECTS.

Physical Defects.

4. Ingots for rolling shall be of uniform quality, tough and sound. They shall be substantially free from blowholes, shrinkage cracks, cold-sets, dross, foreign matter, and other defects

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

in set or casting. Such defects may be waived in ingots which are to be remelted.

III. SAMPLING.

Sampling.

5. If the aluminum is shipped in carload lots, then random samples shall be taken, but not less than five ingots for each car. If the shipment is in less than carload lots, one ingot shall be taken for each 10,000 lb. (4536 kg.) or fractional part thereof.

When it is deemed necessary, a sample may be taken from each heat of 500 lb. (226.8 kg.) or more of metal.

Drilling.

6. The ingots selected shall be drilled completely through, or half through from top and bottom. The drillings shall be fine, thin chips. They should be thoroughly mixed and the sample for analysis should not be less than 60 g.

IV. ANALYSES.

Analyses.

7. The chemical analysis shall be made in accordance with the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (Serial Designation: B 40 - 21 T) of the American Society for Testing Materials.[1]

V. MARKING.

Marking.

8. The maker's brand and the grade of aluminum shall be cast on each ingot. When this is not practicable, the grade shall be indicated by spotting each large ingot, or one ingot in each bundle of small ingots, with a designating color of paint: white indicating the 99.5 grade, blue, the 99.0 grade, and red, the 98.0 grade.

VI. CLAIMS.

Claims.

9. Claims, to be considered, shall be made in writing within ten days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The vender shall within ten days of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 3. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims.

10. The expense of the umpire analysis shall be paid by the loser, or divided in proportion to the concession made, in case of compromise. In case of rejection being established, the damage shall be limited to the payment of freight both ways by the vender for the substitution of an equivalent weight of metal meeting these specifications.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol 21, p. 499 (1921).

TENTATIVE SPECIFICATIONS
FOR
PIG LEAD.[1]

Serial Designation: B 29 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1919; REVISED, 1920, 1922.

Definition. 1. Virgin Lead is lead made from ore or similar raw material by direct processes of reduction and refining, and not produced from reworked metal, and is termed Pig Lead.

Grades. 2. Under these specifications Virgin Lead is considered in three grades, as follows:

I. Corroding Lead.
II. Chemical Lead.
III. Common Lead.

I. MANUFACTURE.

Uniform Quality. 3. The maker shall use care to have each carload of as uniform quality as possible.

II. CHEMICAL PROPERTIES AND TESTS.

(*A*) *Chemical Composition.*

Corroding Lead. 4. Corroding Lead (Grade I) shall conform to the following requirements as to chemical composition:

Silver	not over	0.0015	per cent.
Copper	" "	0.0015	"
Copper and silver together	" "	0.0025	"
Arsenic	" "	0.0015	"
Antimony and Tin together	" "	0.0095	"
Zinc	" "	0.0015	"
Iron	" "	0.002	"
Bismuth	" "	0.05	"
Lead (by difference)		99.9330	"

NOTE.—The maximum limits for bismuth, copper and silver have been given, but it is not expected that any delivery will contain the maximum of all three.

Chemical Lead. 5. Chemical Lead (Grade II) is a designation that has been used for many years in the trade to describe the undesilverized lead produced from Southeastern Missouri ores. This lead contains from 0.04 to 0.08 per cent of copper, from 0.005 to 0.015

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

per cent (1½ to 4½ oz. per ton) of silver and carries less than 0.005 per cent of bismuth.

Common Lead. 6. Common Lead (Grade III) shall conform to the following requirements as to chemical composition:

(*a*) *Desilverized Lead:*

Silver	not over	0.002	per cent.
Copper	" "	0.0025	"
Arsenic, Antimony and Tin together	" "	0.015	"
Bismuth	" "	0.25	"
Iron	" "	0.002	"
Zinc	" "	0.002	"
Lead (by difference)		99.7265	"

(*b*) *Soft Missouri Lead:*[1]

Silver	not over	0.002	per cent.
Copper	" "	0.04	"
Arsenic, Antimony and Tin together	" "	0.015	"
Bismuth	" "	0.005	"
Iron	" "	0.005	"
Zinc	" "	0.002	"
Lead (by difference)		99.931	"

(*B*) *Sampling and Analysis.*

Sampling. 7. (*a*) In sampling, a carload or less shall be considered a lot or unit. One pig shall be taken to represent each ton of lead in the lot. The pigs thus taken shall be sampled by one of the following methods:

(1) By sawing completely through, as illustrated in Fig. 1;

(2) By punching completely through (if equipment permits) or punching half-way through from two opposite sides, as illustrated in Figs. 2 and 3;

(3) By drilling at least half-way through.

(*b*) Whenever the surface of the pigs to be sampled is dirty, care shall be taken to see that none of the dirt or foreign material gets into the sample.

Sawing. 8. If the sample is taken by sawing, the sawdust from all the pigs shall be thoroughly mixed and quartered and the sample for analysis drawn from the mixed material. Care shall be taken that the sawdust is free from all extraneous material.

Punching or Drilling. 9. If the sample is taken by punching or drilling, the holes shall be spaced along a diagonal line from one corner of the pig to the other. Sampling in this manner maybe so arranged that one or more holes are made in each of several pigs of a group in such positions that they represent consecutive positions on the diagonal of a single pig. (See illustration in Fig. 2.)

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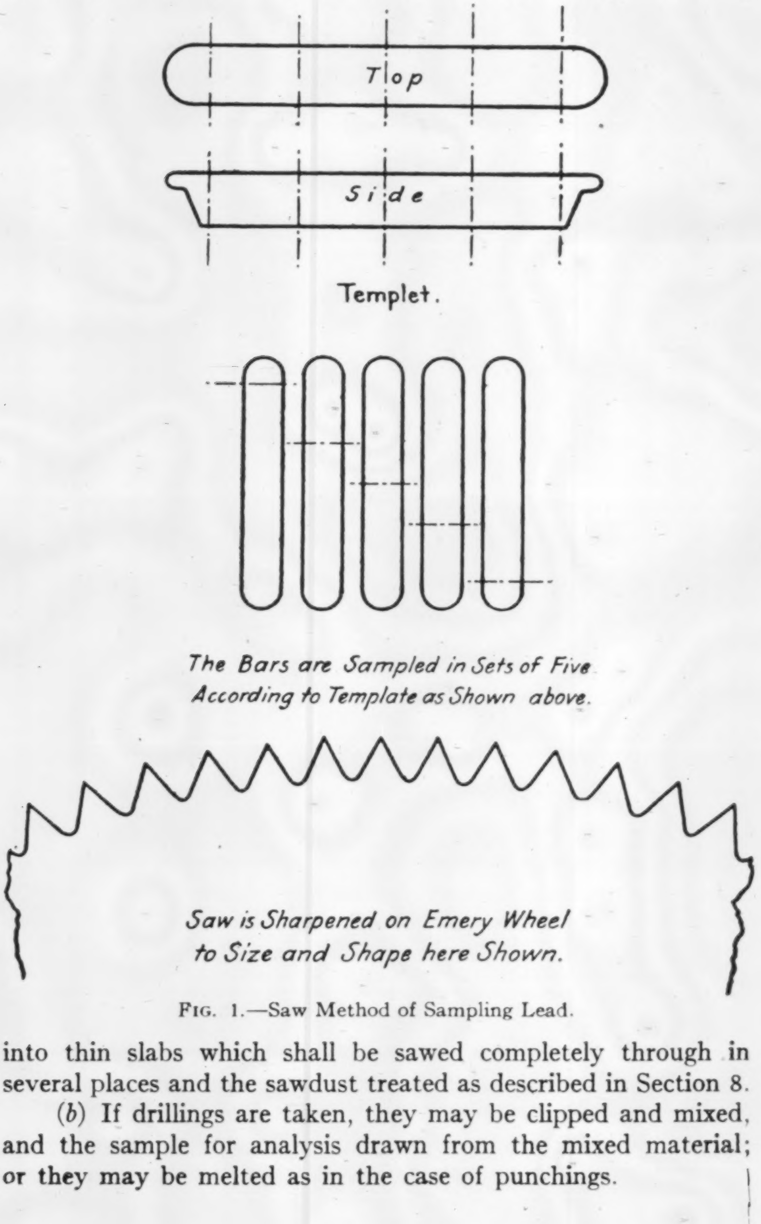
[1] Soft Missouri Lead is a trade name used to cover soft undesilverized lead.

(*a*) If punchings are taken, they may be carefully melted in a clean graphite crucible, and either granulated by carefully pouring into distilled water and thoroughly drying, or casting into thin slabs which shall be sawed completely through in several places and the sawdust treated as described in Section 8.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Side
Templet.
The Bars are Sampled in Sets of Five According to Template as Shown above.
Saw is Sharpened on Emery Wheel to Size and Shape here Shown.

FIG. 1.—Saw Method of Sampling Lead.

(*b*) If drillings are taken, they may be clipped and mixed, and the sample for analysis drawn from the mixed material; or they may be melted as in the case of punchings.

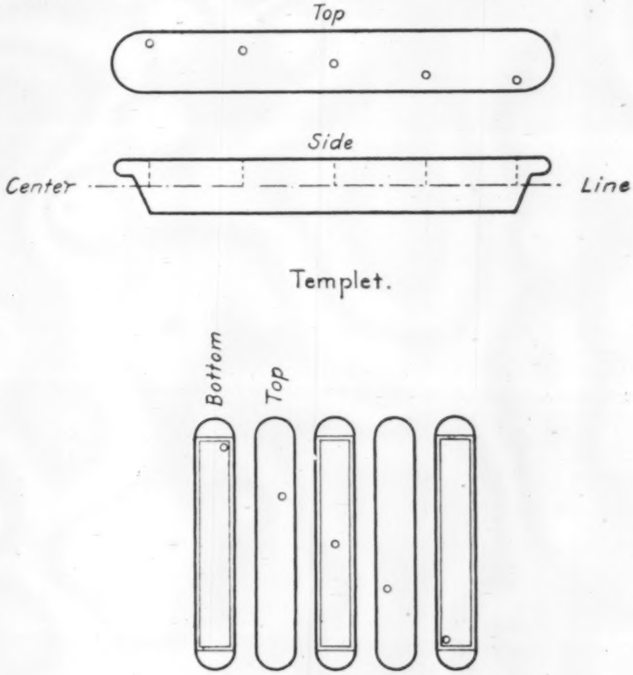
Methods of Chemical Analysis.

10. The chemical analysis shall be made in accordance with the Standard Methods of Chemical Analysis of Pig Lead (Serial Designation: B 35) of the American Society for Testing Materials.[1]

III. MARKING.

Marking.

11. A brand shall be cast or otherwise plainly marked upon each pig by which the maker and grade may be identified.



The Bars Selected as Samples are Placed in a Line with every other Bar, Bottom Side up. The Sampling is Done according to Template in Sets of Five Bars each, as Indicated above. The Punch must be Driven Halfway through the Bar. In Case a Larger Sample is Desired, the Bars are Turned over and Sampled on the other Diagonal.

FIG. 2.—Punch Method of Sampling Lead.

IV. CLAIMS.

Claims.

12. (*a*) Claims, to be considered, shall be made in writing within 30 days of receipt of the material at the purchaser's plant, and the results of the purchaser's tests shall be given. The seller

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[1] 1921 Book of A.S.T.M. Standards.

shall be given one week from date of receipt of such claim to investigate his records, and then shall agree either to satisfy the claim or to the submission of samples to an umpire. No claim shall be considered unless the sample pigs can be shown to the seller's representative.

(*b*) Where the lead satisfies the purity requirements of these specifications, it shall not be condemned for defects in the products in which it is used.

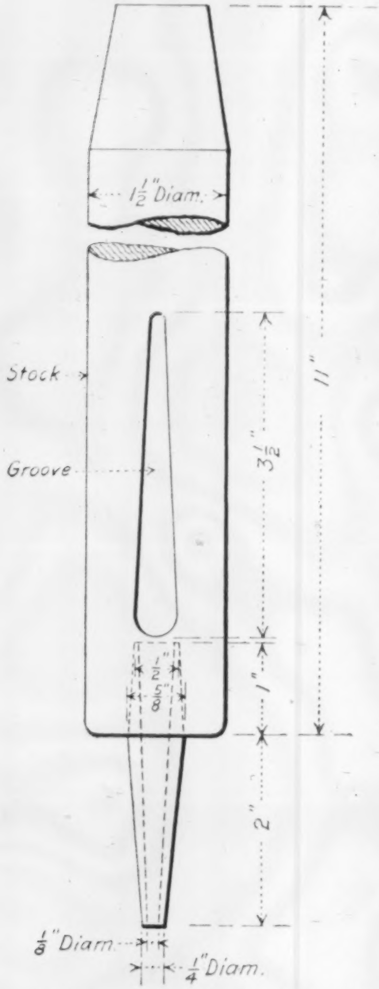

FIG. 3.—Sample Punch for Lead.

Investigation of Claims.

13. On questions of purity a sample shall be drawn by representatives of both parties, as described under "Sampling." The properly mixed and quartered sample shall be separated into three parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality, and whose determination shall be final.

Settlement of Claims.

14. The expense of the seller's representative and of the umpire shall be paid by the loser, or divided in proportion to the concession made in case of compromise. In case of rejection being established, damages shall be limited to the payment of freight both ways by the seller for substitution of an equivalent weight of lead meeting these specifications.

TENTATIVE SPECIFICATIONS
FOR
COPPER PIPE, STANDARD SIZES.[1]

Serial Designation: B 42 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Material Covered. 1. These specifications cover seamless copper tubes and seamless copper pipe suitable for use in plumbing, boiler feed lines, etc.

I. MANUFACTURE.

Process. 2. (*a*) The pipe shall be cold-drawn to size.

(*b*) When pipe is required for bending, the purchaser shall so specify, in which case the pipe shall be furnished with a proper bending temper.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The copper shall have a purity of at least 99.880 per cent as determined by electrolytic assay, silver being counted as copper.

Sampling. 4. The sample for chemical analysis shall consist of drillings, millings, or clippings, taken from the test specimens specified in Section 9, equal quantities being taken from each specimen and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the seller, one for the purchaser, and one for an umpire if necessary.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 5. The material shall conform to the following requirements as to tensile properties:

	Tensile Strength, lb. per sq. in.	Elongation in 4 in., per cent.
Pipe less than 2 in. in outside diameter.............	40 000	10
Pipe 2 in. or over in outside diameter (after annealing)	30 000	25

Bend Tests. 6. (*a*) The test specimen, after being annealed, shall withstand being bent cold through 180 deg. without cracking on the outside of the bent portion as follows: For material less than $\frac{1}{2}$ in. in thickness, flat on itself; and for material $\frac{1}{2}$ in. or over in thickness, around a pin the diameter of whice is twice the thickness of the specimen.

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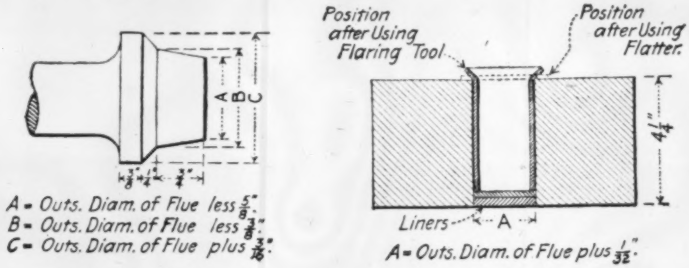
[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

(*b*) In the case of pipe for bending, annealed full sections of the pipe shall withstand being bent cold through 180 deg. without cracking on the outside of the bent portion, around a pin the diameter of which is $1\frac{1}{2}$ times the inside diameter of the pipe. This test shall be in addition to the test specified in Paragraph (*a*).

Flange Test. 7. (*a*) An annealed test specimen, not more than 4 in. in length shall have a flange turned over at right angles to the body of the pipe without showing cracks or flaws. The width of this flange, as measured from the outside of the pipe, shall be one-fourth of the inside diameter of the pipe.


A
B
C
3/8"
1/4"
3/4"
A = Outs. Diam. of Flue less 5/8".
B = Outs. Diam. of Flue less 3/8".
C = Outs. Diam. of Flue plus 3/16".
Position after Using Flaring Tool
Position after Using Flatter.
4 1/4"
Liners
A
A = Outs. Diam. of Flue plus 1/32".

Flaring Tool. Die Block.

FIG. 1.

(*b*) In making the flange test, it is recommended that the flaring tool and die block shown in Fig. 1 be used.

Hydrostatic Test. 8. Each pipe shall withstand, without showing weakness or defects, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 6000 lb. per sq. in., determined by the formula for thin hollow cylinders under tension:

$$P = 2\,\frac{t\,S}{D}$$

in which P equals the pressure in pounds per square inch, t equals the thickness of wall in inches, D equals the inside diameter of the pipe in inches, and S equals the allowable unit stress of the material = 6000 lb. per sq. in. No pipe shall be tested beyond a pressure of 1000 lb. per sq. in. unless so specified.

Test Specimens. 9. (*a*) Tension test specimens for pipe less than 2 in. in outside diameter shall consist of a full section of the unannealed pipe; the ends shall be plugged with metal plugs which shall not extend within the gage marks.

(*b*) In the case of pipe 2 in. or over in outside diameter and not exceeding 6 in. in outside diameter, the test specimen shall be cut longitudinally. In the case of pipe exceeding 6 in. in outside diameter, the test specimen shall be cut circumferentially.

(*c*) The test specimen taken as specified in Paragraph (*b*), shall be heated to a cherry red and straightened while hot. It shall then be machined to conform in shape to Fig. 2. The width of the specimen shown in Fig. 2 shall be governed by the thickness of the material. For material $\frac{1}{4}$ in. or less in thickness, the width of the narrow portion of the test specimen shall be approximately 1 in.; for material over $\frac{1}{4}$ in. in thickness, the width shall be such as to give a cross-section of approximately $\frac{1}{4}$ sq. in. in area, but in no case shall the width be less than the thickness of the material. The drawn surfaces shall not be machined, but be left in their original condition.

(*d*) The bend test specimen shall consist of a strip not over $1\frac{1}{2}$ in. in width, cut longitudinally from the pipe.

Number of Tests.

10. One bend test shall be made for each 2000 lb. or less of the finished product. For the remaining tests, a sufficient number of pipe shall be taken at random to constitute 0.5 per cent of the shipment.

IV. DIMENSIONS AND PERMISSIBLE VARIATIONS.

Standard Weights.

11. The standard weights and dimensions for pipe of various outside diameters are as follows:

SIZE OF PIPE, IN.	OUTSIDE DIAMETER, IN.	INSIDE DIAMETER, IN.	THICKNESS, IN.	NOMINAL WEIGHT, LB. PER FT. OF LENGTH.
$\frac{1}{8}$	0.405	0.281	0.0620	0.259
$\frac{1}{4}$	0.540	0.375	0.0825	0.461
$\frac{3}{8}$	0.675	0.494	0.0905	0.643
$\frac{1}{2}$	0.840	0.625	0.1075	0.957
$\frac{3}{4}$	1.050	0.822	0.1140	1.30
1	1.315	1.062	0.1265	1.83
$1\frac{1}{4}$	1.660	1.368	0.1460	2.69
$1\frac{1}{2}$	1.900	1.600	0.1500	3.20
2	2.375	2.062	0.1565	4.23
$2\frac{1}{2}$	2.875	2.500	0.1875	6.14
3	3.500	3.062	0.2190	8.75
$3\frac{1}{2}$	4.000	3.500	0.2500	11.41
4	4.500	4.000	0.2500	12.94
$4\frac{1}{2}$	5.000	4.500	0.2500	14.46
5	5.563	5.062	0.2505	16.21
6	6.625	6.125	0.2500	19.41
7	7.625	7.062	0.2815	25.17
8	8.625	8.000	0.3125	31.63
9	9.625	8.937	0.3440	38.88
10	10.750	10.019	0.3655	46.22

Permissible Variations. 12. (*a*) No single piece of pipe that exceeds the calculated weight by more than 5 per cent will be accepted. One cubic inch of the material is assumed to weigh 0.323 lb.

(*b*) The weight of the pipe shall vary not more than the following percentages from the weight specified in Section 11: Pipe 6 in. or less in diameter, 5 per cent; pipe from 6 to 8 in. in diameter, 7 per cent; pipe over 8 in. in diameter, 8 per cent.

V. WORKMANSHIP AND FINISH.

Workmanship. 13. (*a*) The pipe shall be round and of uniform thickness throughout. They shall be free from cracks, seams, slivers, scale and other surface defects.

(*b*) The thickness at any point shall not be less than that specified in Section 11 by more than the following percentages: Pipe 6 in. or less in diameter, 5 per cent; pipe from 6 to 8 in. in diameter, 7 per cent; pipe over 8 in. in diameter, 8 per cent.

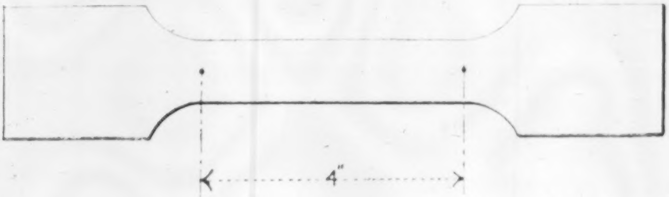


FIG. 2.

VI. INSPECTION AND REJECTION.

Rejection. 14. When the pipe is finished, and ready for shipment, the inspector shall make the tests to govern the acceptance of the pipe. If any specimen fails to meet the requirements of Sections 5 to 8, inclusive, two additional specimens may be taken, each of which shall conform to the requirements specified.

Inspection. 15. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified and shall be so conducted as not to interfere unnecessarily with the operation of the works.

TENTATIVE SPECIFICATIONS
FOR
BRASS PIPE, STANDARD SIZES.[1]

Serial Designation: B 43 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1922.

Material Covered. 1. These specifications cover seamless brass pipe suitable for use in plumbing, boiler feed lines, etc.

I. MANUFACTURE.

Process. 2. The pipe shall be cold-drawn to size.

Annealing. 3. (*a*) The pipe shall be annealed sufficiently to enable it to pass the physical tests herein specified.

(*b*) All pipe shall be annealed sufficiently to prevent cracking. Semi-annealed pipe, which is suitable for ordinary uses, shall be furnished unless otherwise specified.

(*c*) When pipe is required for bending, the purchaser shall so specify, in which case the pipe shall be furnished fully annealed.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 4. The brass shall conform to the following requirements as to chemical composition.

	Hot Pierced Process.	Cold Process.
Copper, per cent.................	59.00 - 63.00	65.00 - 68.00
Lead, maximum, per cent.........	0.50	0.80
Iron, maximum, per cent..........	0.07	0.07
Zinc............................	Remainder	Remainder

Sampling. 5. The sample for chemical analysis shall consist of drillings, millings, or clippings taken from the pipes selected for testing purposes, as specified in Section 12, equal quantities being taken from each pipe and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the seller, one for the purchaser, and one for an umpire, if necessary.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

III. PHYSICAL PROPERTIES AND TESTS.

Hammering Test.

6. The pipe shall be capable of withstanding the following test without showing cracks or flaws: A piece cut from the ends of the pipe shall be hammered flat on different elements throughout its length so that a gage set at 3 times the thickness of the metal shall pass over the pipe freely throughout the flattened part, except at such points where changes in the elements of flattening take place.

Flattening Test.

7. A test specimen 3 in. in length when split, shall withstand opening out flat without showing cracks or flaws.

Strain Test.

8. A test specimen 3 in. in length shall withstand an immersion in an aqueous mercurous nitrate solution containing 100 g. of mercurous nitrate and 13 cc. of nitric acid (sp. gr. 1.42) per liter of solution for 15 minutes, without cracking.

Threading Test.

9. The pipe shall withstand threading in a satisfactory manner.

Bending Test.

10. In the case of pipe for bending, annealed full sections of the pipe shall withstand being bent cold through 180 deg. without cracking on the outside of the bent portion around a pin the diameter of which is $1\frac{1}{2}$ times the inside diameter of the pipe. This test shall be in addition to the tests specified in Sections 6 to 9, inclusive.

Hydrostatic Test.

11. Each pipe shall withstand, without showing weakness or defects, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 7000 lb. per sq. in., determined by the formula for thin hollow cylinders under tension:

$$P = 2\,\frac{t\,S}{D}$$

in which P equals the pressure in pounds per square inch, t equals the thickness of wall in inches, D equals the inside diameter of the pipe in inches, and S equals the allowable unit stress of the material = 7000 lb. per sq. in. No pipe shall be tested beyond a pressure of 1000 lb. per sq. in. unless so specified.

Number of Tests.

12. A sufficient number of pipe shall be taken at random to constitute 0.5 per cent of the shipment. One flattening, one strain, and one threading test shall be made on each pipe so selected.

IV. DIMENSIONS AND PERMISSIBLE VARIATIONS.

Standard Weights.

13. The standard weights and dimensions for pipe of various outside diameters are as follows:

Size of Pipe, in.	Outside Diameter, in.	Inside Diameter, in.	Thickness, in.	Nominal Weight, lb. per ft. of length.
⅛	0.405	0.281	0.0620	0.246
¼	0.540	0.375	0.0825	0.437
⅜	0.675	0.494	0.0905	0.612
½	0.840	0.625	0.1075	0.911
¾	1.050	0.822	0.1140	1.24
1	1.315	1.062	0.1265	1.74
1¼	1.660	1.368	0.1460	2.56
1½	1.900	1.600	0.1500	3.04
2	2.375	2.062	0.1565	4.02
2½	2.875	2.500	0.1875	5.83
3	3.500	3.062	0.2190	8.31
3½	4.000	3.500	0.2500	10.85
4	4.500	4.000	0.2500	12.29
4½	5.000	4.500	0.2500	13.74
5	5.563	5.062	0.2505	15.40
6	6.625	6.125	0.2500	18.44
7	7.625	7.062	0.2815	23.92
8	8.625	8.000	0.3125	30.05
9	9.625	8.937	0.3440	36.94
10	10.750	10.019	0.3655	43.91

Permissible Variations.

14. (*a*) No single piece of pipe that exceeds the calculated weight by more than 5 per cent will be accepted. One cubic inch of the material is assumed to weigh 0.307 lb.

(*b*) The weight of the pipe shall vary not more than the following percentages from the weight specified in Section 13, Pipe 6 in. or less in diameter, 5 per cent; pipe from 6 to 8 in. in diameter, 7 per cent; pipe over 8 in. in diameter, 8 per cent.

V. WORKMANSHIP AND FINISH.

Workmanship.

15. (*a*) The pipe shall be round and of uniform thickness throughout. They shall be free from cracks, seams, slivers, scale and other surface defects.

(*b*) The thickness at any point shall not be less than that specified in Section 13 by more than the following percentages: Pipe 6 in. or less in diameter, 5 per cent; pipe from 6 to 8 in. in diameter, 7 per cent; pipe over 8 in. in diameter, 8 per cent.

Finish.

16. All pipes shall be acid cleaned after the final annealing.

VI. INSPECTION AND REJECTION.

Rejection. 17. (*a*) When the pipe is finished, and ready for shipment, the inspector shall make the tests to govern the acceptance of the pipe. If any specimen fails to meet the requirements of Sections **6** to 11, inclusive, two additional specimens may be taken, each of which shall conform to the requirements specified.

(*b*) Pipes that show non-uniform annealing under handling shall be rejected from the lot.

Inspection. 18. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified and shall be so conducted as not to interfere unnecessarily with the operation of the works.

TENTATIVE SPECIFICATIONS
FOR
SEAMLESS ADMIRALTY CONDENSER TUBES AND FERRULE STOCK.[1]

Serial Designation: B 44 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Material Covered. 1. These specifications cover seamless tubes and ferrule stock made from Admiralty alloy for condenser use.

I. MANUFACTURE.

Process. 2. The tubes shall be cold-drawn to size.

Annealing. 3. (*a*) Condenser tubes shall be annealed sufficiently to enable the tubes to pass the physical and metallographic tests herein specified.

(*b*) Tubes for ferrule stock shall be sufficiently annealed to prevent cracking, but they need not be held within the close limits prescribed for condenser tubes.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 4. The material shall conform to the following requirements as to chemical composition (Note 1):

Copper, minimum, per cent	70.00
Tin, minimum, per cent	0.90
Lead, maximum, per cent	0.075
Iron, maximum, per cent	0.06
Zinc	Remainder

Sampling. 5. The sample for chemical analysis shall consist of drillings, millings, or clippings taken from at least three separate tubes from each lot of 600 tubes or less, equal quantities being taken from each tube and thoroughly mixed. Samples so prepared shall be divided into three equal parts each of which shall be placed in a sealed package, one for the seller, one for the purchaser, and one for an umpire, if necessary.

III. PHYSICAL PROPERTIES AND TESTS.

Microscopic Examination. 6. (*a*) A microscopic examination of the tubes shall show sufficient annealing for complete recrystallization with a uniform grain size not in excess of 0.045 mm. in average diameter, the grain size approaching as closely as possible a mean diameter of between 0.015 and 0.035 mm. (Note 2).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

(*b*) The examination of specimens for the determination of grain size shall be made at a magnification of 75 diameters.

Hammering Test. 7. The tubes shall be capable of withstanding the following test without showing cracks or flaws: A piece cut from the ends of the tube shall be hammered flat on different elements throughout its length so that a gage set at 3 times the thickness of the metal shall pass over the tube freely throughout the flattened part, except at such points where changes in the elements of flattening take place.

Expanding Test. 8. The tubes shall be capable of withstanding the following test without showing signs of cracking or rupture: a pin having a taper of $1\frac{1}{2}$ in. per ft. shall be driven into the tube until the diameter has been increased $16\frac{2}{3}$ per cent.

Strain Test. 9. A test specimen 3 in. in length shall withstand an immersion in an aqueous mercurous nitrate solution containing 100 g. of mercurous nitrate and 13 cc. of nitric acid (sp. gr. 1.42) per liter of solution for 15 minutes, without cracking (Note 3).

Hydrostatic Test. 10. All tubes shall withstand an internal hydrostatic pressure of 1000 lb. per sq. in. without leakage and shall show no sign of strain or cracking (Note 4).

Number of Tests. 11. Tubes shall be grouped into lots of 600 tubes or less. Two tubes shall be selected from each lot and subjected to the physical tests specified in Sections 6 to 9, inclusive.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Thickness. 12. (*a*) No tube at its thinnest point shall be less than the thickness specified.

(*b*) For finished tubes having a specified thickness of 0.035 to 0.049 in., the thickness shall not exceed that specified by more than 0.005 in. For tubes having a specified thickness of 0.065 to 0.083 in., the thickness shall not exceed that specified by more than 0.007 in.

Length. 13. The length shall not be less but may be $\frac{1}{16}$ in. more than that ordered when measured at a temperature of 70° F.

Weight. 14. No single tube that exceeds the calculated weight by more than 5 per cent will be accepted. One cubic inch of the material is assumed to weigh 0.308 lb.

V. WORKMANSHIP AND FINISH.

Workmanship. 15. The tubes shall be round and of uniform thickness throughout. They shall be free from cracks, seams, slivers, scale and other surface defects both inside and out.

Finish. 16. All tubes shall be acid cleaned after the final annealing.

VI. INSPECTION AND REJECTION.

Rejection. 17. If any test specimen representing a lot fails to meet the requirements of Section 4 and Sections 6 to 9, inclusive, two additional specimens, at the option of the manufacturer, may be taken as before and submitted for check analysis or subjected to any tests in which the original specimen failed, but each of these specimens shall conform to the requirements specified.

Inspection. 18. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

EXPLANATORY NOTES.

NOTE 1.—The ideal composition for Admiralty metal is 70 per cent of copper, 29 per cent of zinc, 1 per cent of tin, and better tubes will be obtained by adhering as closely as possible to this composition, particularly as to tin. It does not, therefore, seem wise to make 1 per cent of tin the minimum but rather in order to obtain as nearly 1 per cent as possible to allow some variation under 1 per cent and make the minimum limit for tin 0.90 per cent.

NOTE 2.—The so-called "Compression Test" requiring that tubes of varying sizes and thicknesses should be subjected to certain arbitrary pressures without more than 0.005 in. permanent deformation has not been included because the elastic limit of the tube under compression is a function of the temperature at which it receives its final heat treatment and the metallographic examination sufficiently determines the temper of the tube to decide whether it may be properly packed in the condenser head.

NOTE 3.—Since the specification requires that the tubes shall be annealed sufficiently to establish crystallin equilibrium and show a grain size within certain definite limits, it would seem that a test for internal strains might be unnecessary. The mercurous nitrate test has been included, however, to guard against the hardening of tubes by light drawing operations which would not deform the crystals to an extent recognizable by microscopic examination.

NOTE 4.—Provision is made for the testing of each tube separately to 1000 lb. per sq. in. hydrostatic pressure in order to develop and make evident fractures or punctures which may have occurred in the process of manufacture. This is a 100 per cent test and it is not necessary to again test all the tubes by subjecting them to 80 lb. per sq. in. pneumatic pressure while immersed in water. Both of these tests are made to detect the same kind of faults and either if carried out according to the intent of the specifications should be sufficient. The 1000-lb. hydrostatic pressure test is the more searching and has been specified. The multiplication of tests to determine the same facts under the plea that there may be carelessness in applying one or another should not be encouraged.

TENTATIVE METHODS OF CHEMICAL ANALYSIS
OF
BRASS INGOTS AND SAND CASTINGS.[1]

Serial Designation: B 45 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1922

In the alloys containing the higher amounts of zinc this element is taken by difference. For determination of smaller amounts of zinc, see the Tentative Methods of Chemical Analysis of Bronze Bearing Metal (Serial Designation: B 46 - 22 T) of the American Society for Testing Materials.[2]

DETERMINATION OF COPPER
BY THE
ELECTROLYTIC METHOD.

APPARATUS FOR ELECTROLYSIS.

Electrodes.—The electrodes recommended are of the stationary and not of the rotating type, as the stationary require less of the operator's time and there is less chance for erroneous results to be obtained than with the other kind. Rapid and accurate results are obtained with stationary electrodes made from platinum gauze.

Cathodes.—Platinum cathodes may be formed either from plain or perforated sheets, or from wire gauze, and may be either open or closed cylinders. They should give a depositing surface, counting both sides, of approximately 100 sq. cm. Gauze cathodes are recommended, and are best made from gauze containing approximately 400 meshes per sq. cm. (30 meshes per linear inch). The cathode should be stiffened by doubling the gauze for about 3 mm. at the top and at the bottom of the cylinder. The cylinder should be approximately 30 mm. in diameter and 30 mm. in height. The stem should be made from 1.14-mm. or 1.29-mm. wire, flattened and welded the entire width of the gauze; the height over all should be approximately 130 mm., and the gauze should be sand blasted.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

[2] See p. 674.

Anodes.—Platinum anodes may be of the spiral type when used in the determination of copper by electrolysis, or in the electrolytic determination of lead when it is present in amounts not over 0.2 per cent. When used in the electrolytic determination of copper and lead together in samples containing 0.2 per cent of lead or over, the anodes should be of wire gauze. Spiral anodes should be made from 1.02-mm. or 1.14-mm. wire formed into a spiral of 7 turns having a height of approximately 51 mm. and a diameter of 16 mm., the length over all being approximately 145 mm. Platinum gauze used in making anodes should contain approximately 400 meshes per sq. cm. (50 meshes per linear inch). The gauze should be formed into closed cylinders approximately 12 mm. in diameter and 30 mm. in height. The cylinders should be stiffened by doubling the gauze for about 3 mm. at the top and at the bottom. The stem should be made from 1.02-mm. or 1.29-mm. wire, flattened and welded the entire width of the gauze; the height over all should be approximately 130 mm., and the gauze should be sand blasted.

METHOD.

In a 150-cc. beaker, dissolve 1 g. of brass in 10 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, evaporate the solution to dryness, and bake thoroughly on the edge of a hot plate. Moisten thoroughly with HNO_3 (sp. gr. 1.42), and after digesting for a short time dilute to 50 cc. with hot distilled water, heat to boiling, and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on double 7-cm. papers, keeping the solution hot, and receive the filtrate in a 200-cc. electrolysis beaker. Wash with boiling hot water. Add to the filtrate 5 cc. of H_2SO_4 (sp. gr. 1.84), and evaporate until copious fumes of H_2SO_4 are evolved. Dilute to about 100 cc. with distilled water, add 1.5 cc. of HNO_3 (sp. gr. 1.42), insert electrodes, cover with a pair of split watch glasses and electrolyze. For each solution use a current over night of 0.5 ampere at approximately 10 volts, or else use a current of 4 amperes at approximately 10 volts continued for about $2\frac{1}{2}$ hours. The latter case requires the use of gauze cathodes. When the solution is colorless, wash down the cover glasses, electrodes, and sides of the beaker, raising the level of the liquid slightly, and continue the electrolysis about 15 minutes, noting whether or not copper is deposited on the newly exposed surface of the platinum. If no copper appears, transfer about 1 cc. of the colorless solution to the cavity of a porcelain test plate, and add a few drops of fresh H_2S water. If the slightest discoloration occurs, continue the electrolysis, repeating the test. Remove the cathode quickly, rinse it in distilled water and then dip it in two successive baths of alcohol. Shake off the excess alcohol and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually as the alcohol burns. Weigh as metallic copper.

Accuracy.—Duplicate determinations should check within 0.10 per cent of copper.

NOTES.

In alloys of this type which carry considerable iron, it is impossible to remove the tin quantitatively as meta-stannic acid (H_2SnO_3), notwithstanding the preliminary baking. Upon testing (by the addition of H_2S water), the liquid in the pits of the test plate may be colored yellow, due to the tin present, but there should be no darkening due to the presence of copper. If the cathode appears dark, as though tin had been deposited on it, dissolve the coating in 10 cc. of HNO_3 (sp. gr. 1.42), filter off the tin as before, add to the filtrate 5 cc. of H_2SO_4 (sp. gr. 1.84), and redeposit the copper by electrolysis. It is rarely necessary thus to purify the deposited copper.

A slight amount of copper is retained by the meta-stannic acid (H_2SnO_3), which should be recovered in very accurate work but is generally neglected in routine analysis.

DETERMINATION OF LEAD
BY THE
ELECTROLYTIC METHOD.

In a 250-cc. beaker, dissolve 1 g. of brass in 25 cc. of HNO_3 (sp. gr. 1.42). Allow the solution to bake dry on the edge of a hot plate or by standing over night on the steam-bath. Add 17 cc. of HNO_3 (sp. gr. 1.42), and after digesting for a short time, add 85 cc. of hot water and heat to boiling for a few minutes. Allow the solution to stand for several hours at a temperature just below the boiling point. Filter off the precipitated H_2SnO_3 on double closely woven filter papers, being careful to keep the solution hot throughout the process of filtration. Wash with boiling water. Receive the combined filtrate and washings in a 250-cc. beaker. Dilute to about 150 cc. with distilled water and insert electrodes. In the positive terminal use a sand-blasted platinum gauze electrode such as is used for the cathode in the "Determination of Copper by the Electrolytic Method"; in the negative terminal insert an electrode such as is used for the anode in the "Determination of Copper by the Electrolytic Method."

Cover with a pair of split watch glasses and electrolyze. For each solution use a current of 1.25 to 1.5 amperes at 10 volts continued for about one hour. Wash down the cover glasses, electrodes and sides of the beaker, raising the level of the liquid slightly, and continue the electrolysis for 15 minutes. If no darkening of the newly exposed surface of the platinum can be detected the lead has been entirely deposited. Continue the electrolysis until no darkening of the platinum can be detected when the current has been passed for 15 minutes after the level of the liquid has been raised.

When the lead has been entirely deposited, remove the anode quickly, rinse it in distilled water and then in alcohol, and dry it at 210° C. for 30 minutes. Weigh as PbO_2, using for lead 0.8643 instead of the theoretical value.

Accuracy.—Duplicate determinations should check within 0.01 per cent of lead. Results obtained by this method are likely to be about 0.01 per cent too high. For exceptionally accurate or investigation work redissolve the coating from the electrode and determine the lead as sulfate. See the "Determination of Lead as Sulfate (Optional)."

NOTES.

It is impossible to remove the tin quantitatively as H_2SnO_3 in the case of alloys containing over 0.25 per cent of iron, and traces of tin are sometimes found in the PbO_2 deposit.

In this and in the following method, a slight amount of lead may be retained by the H_2SnO_3. This should be recovered in very accurate work, but is neglected in a routine analysis.

DETERMINATION OF LEAD
AS
SULFATE.
(OPTIONAL.)

SOLUTIONS REQUIRED.

"*Lead Acid.*"—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 1800 cc. of distilled water. Dissolve 1 g. of lead acetate, c. p., in 300 cc. of distilled water and add this to the hot solution, stirring meanwhile. Let stand at least 24 hours and syphon through a thick asbestos filter.

Dilute Alcohol for Washing.—Mix equal parts of denatured alcohol and distilled water.

METHOD.

In a 250-cc. beaker, dissolve 1 g. of brass in 25 cc. of HNO_3 (sp. gr. 1.42). Allow the solution to bake dry on the edge of a hot plate, or by standing over night on the steam bath. Add 17 cc. of HNO_3 (sp. gr. 1.42), and after digesting for a short time, add 85 cc. of hot water and heat to boiling for a few minutes. Allow the solution to stand for several hours at a temperature just below the boiling point. Filter off the precipitated H_2SnO_3 on double closely woven filter papers, being careful to keep the solution hot throughout the process of filtration. Wash with boiling hot water. To the combined filtrate and washings, add 40 cc. of lead acid, and evaporate until copious fumes of H_2SO_4 are evolved. Cool, add 35 cc. of distilled water to dissolve the salts and to make the acid concentration the same as in lead-acid, heat to boiling, and allow to cool and settle for 5 hours, or over night if convenient. Filter on a weighed porcelain Gooch crucible and wash with lead acid. Wash out the lead acid with dilute alcohol, set the Gooch crucible inside a porcelain crucible, dry and ignite for 5 minutes at the full heat of a Tirrill burner, cool and weigh as $PbSO_4$, which contains 68.29 per cent of lead.

Accuracy.—Duplicate determinations should check within 0.01 per cent of lead. Results obtained by this method are likely to be about 0.01 per cent too low.

NOTE.

It is impossible to remove the tin quantitatively as H_2SnO_3 in the case of alloys containing over 0.25 per cent of iron, but by the preliminary baking and long standing, most of the H_2SnO_3 is precipitated.

DETERMINATION OF COPPER AND LEAD SIMULTANEOUSLY BY THE ELECTROLYTIC METHOD.

METHOD.

In a 150-cc. beaker, dissolve 1 g. of brass in 10 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, evaporate the solution to dryness, and bake thoroughly on the edge of a hot plate. Add 10 cc. of HNO_3 (sp. gr. 1.42), and after digesting for a short time add 50 cc. of hot distilled water, heat to boiling, and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on double 7-cm. filter paper, keeping the solution hot, and receive the filtrate in a 200-cc. electrolysis beaker. Wash with boiling water, dilute to about 100 cc. and insert electrodes. In the positive terminal insert one of the platinum gauze anodes previously described, and in the negative terminal insert a platinum gauze cathode. Cover with a pair of split watch glasses and electrolyze, using a current of from 3 to

5 amperes at approximately 10 volts for each solution. After about 45 minutes, the lead will have been entirely deposited on the anode as PbO_2; without interrupting the current add to the electrolyte 3 to 4 cc. of H_2SO_4 (sp. gr. 1.84), and continue the electrolysis. When the solution is colorless, wash down the cover glasses, electrodes and sides of the beaker, raising the level of the liquid slightly, and continue the passage of the current for about 15 minutes, noting whether or not copper is deposited on the newly exposed surface of the platinum. If no copper appears, transfer about 1 cc. of the colorless solution to the cavity of a porcelain test plate, and add a few drops of fresh H_2S water. If the slightest discoloration occurs, continue the electrolysis until there is no discoloration whatever upon repeating the test. Remove the solution from the electrodes quickly without interrupting the current. Rinse the electrodes in distilled water and then dip them in two successive baths of alcohol. Dry the anode at 210° C. for 30 minutes. Weigh as PbO_2, using the factor for lead 0.8643 instead of the theoretical value. Shake off the excess alcohol from the cathode and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

Accuracy.—Duplicate copper determinations should check within 0.10 per cent of copper. Duplicate lead determinations should check within 0.02 per cent of lead. Lead results obtained by this method are likely to be about 0.01 per cent too high. See notes under the "Determination of Lead by the Electrolytic Method."

DETERMINATION OF TIN.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid.—Mix 500 cc. of HCl (sp. gr. 1.20) and 500 cc. of distilled water.

Dilute Sulfuric Acid.—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 600 cc. of distilled water.

Dilute Ammonia.—Mix 100 cc. of NH_4OH (sp. gr. 0.90) and 900 cc. of distilled water.

Ammonium Acetate Solution for Washing.—Dissolve 10 g. of ammonium acetate in 300 cc. of distilled water. Make slightly acid with acetic acid and saturate with H_2S gas.

METHOD.

In a 150-cc. beaker, dissolve 1 g. of brass in a mixture of 10 cc. of HCl (sp. gr. 1.20) and 5 cc. of HNO_3 (sp. gr. 1.42). Dilute to about

75 cc. with distilled water. Add NH_4OH (sp. gr. 0.90) until the basic salts of copper have dissolved and the solution has become a deep blue. Boil and allow to settle and filter on a closely woven filter paper. Wash with dilute ammonia and with hot water. Dissolve the precipitate on the filter with hot dilute HCl. Dilute the solution to about 100 cc. Add NH_4OH (sp. gr. 0.90) until a permanent precipitate forms. Heat the solution to boiling, allow to settle, filter and wash as before. Dissolve the precipitate on the filter with boiling hot dilute H_2SO_4, washing the paper very thoroughly with this acid. Add NH_4OH (sp. gr. 0.90) cautiously until the precipitate which forms at first dissolves rather slowly. Allow the solution to stand for some hours and if any lead sulfate forms filter it off. Dilute the solution to about 200 cc. and saturate it with H_2S gas. Filter the precipitated tin sulfide off on double papers and wash with ammonium acetate solution, retaining the filtrate and washings for the iron determination. Dry the precipitate and place it with the papers in a porcelain crucible which projects part way through a hole in a piece of asbestos board. Heat slowly until any free sulfur has been driven off, but without allowing the sulfur to burn. When the sulfur has been expelled, place the crucible on a triangle and ignite slowly at first and finally at the full heat of the burner. If the precipitate weighs more than 20 mg., heat to constant weight, using a blast lamp. Weigh as SnO_2, which contains 78.81 per cent of tin.

Accuracy.—Duplicate determinations should check within 0.06 per cent of tin.

NOTES.

If, during ignition, the sulfur is allowed to burn, some tin sulfate may be formed, causing high results. On the other hand, low results may be caused by too high heat, which causes spattering and volatilizes some tin sulfide.

Tin and iron are best determined on the same sample, retaining the filtrate from the tin sulfide precipitate to use for the iron determination.

DETERMINATION OF IRON.

SOLUTIONS REQUIRED.

See "Determination of Tin."

Dilute Sulfuric Acid for Reductor.—Mix 50 cc. of H_2SO_4 (sp. gr. 1.84) and 1000 cc. of distilled water. This solution is used boiling hot.

Potassium Permanganate.—Dissolve 0.2 g. of $KMnO_4$ in water, filter through asbestos, and dilute to 1000 cc. with distilled water. Standardize against 0.020-g. portions of pure sodium oxalate. Each cubic centimeter is equivalent to approximately 0.00033 g. of iron.

METHOD.

Proceed exactly as in the "Determination of Tin" through the filtration and washing of the precipitated tin sulfide. Combine the filtrate and washings from the tin sulfide precipitate and boil until all H_2S is expelled. Add HNO_3 (sp. gr. 1.42) until the iron is oxidized, which is shown by the solution becoming clear and of a yellowish color. Add about 5 g. of NH_4Cl, then NH_4OH (sp. gr. 0.90) until a permanent precipitate forms. Boil, allow to settle, filter on a loosely woven filter paper and wash with dilute ammonia and with hot water. Dissolve the precipitate on the paper with hot dilute HCl and add NH_4OH (sp. gr. 0.90) to the solution again until a permanent recipitate forms. Boil, allow to settle, filter on a loosely woven filter paper, and wash with dilute ammonia and with hot water until all NH_4Cl is removed. Dissolve the precipitate and wash the filter paper with 100 cc. of dilute H_2SO_4 for reductor. Pass the solution through a Jones reductor, wash first with 150 cc. of the H_2SO_4 for reductor and then with 100 cc. of distilled water. Titrate with the standard $KMnO_4$ Solution.

Accuracy.—Duplicate determinations should check within 0.03 per cent of iron.

NOTES.

A blank determination should be made on corresponding amounts of acid and water passed through the reductor and the results should be corrected accordingly. About 0.5 cc. of the permanganate will be required to give a permanent coloration to the solution.

A small quantity of liquid should always be left in the reductor funnel, and air should never be allowed to enter the body of the reductor.

For a description and further details of use of reductor see "The Chemical Analysis of Iron" by A. A. Blair, or "Quantitative Chemical Analysis" by H. P. Talbot.

DETERMINATION OF ANTIMONY
BY THE
VOLUMETRIC METHOD.

SOLUTIONS REQUIRED.

Potassium Permanganate.—Dissolve 0.3 g. of potassium permanganate in 1000 cc. of distilled water. Standardize by dissolving 25 mg. of pure antimony in 15 cc. of boiling sulfuric acid and proceed according to the method from this point.

METHOD.

In a 250-cc. beaker dissolve 5 g. of brass in 25 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, boil until the oxides of nitrogen are expelled, add 125 cc. of boiling water and allow to stand and settle for one hour or longer, keeping the temperature just below the boiling point. Filter on double 9-cm. closely woven papers, keeping the solution hot. Wash with boiling water. Discard the filtrate.

Transfer the papers containing the tin and antimony to a 350-cc. Erlenmeyer flask and add 25 cc. of HNO_3 (sp. gr. 1.42), 5 g. of ammonium persulfate, and 15 cc. of H_2SO_4 (sp. gr. 1.84). Boil to strong fumes of SO_3. If the solution is brown, *cool* and add 5 cc. of HNO_3 (sp. gr. 1.42) and a little more (1 g. or less) persulfate, if necessary, and boil again to strong fumes of SO_3. When the solution is colorless, cool, add 20 cc. of distilled water, 20 cc. of HCl (sp. gr. 1.20) and 1 g. of sodium sulfite. Boil gently for 10 minutes to expel SO_2 completely. Dilute with 200 cc. of distilled water and cool to 10 to 12° C. in ice or under running water.

Titrate with standard permanganate solution until the appearance of a decided pink color.

NOTES.

1. In alloys containing a large excess of tin, the antimony is precipitated quantitatively with the meta-stannic acid.
2. Ammonium persulfate and nitric acid are used to destroy the filter paper, and subsequent boiling with sulfuric acid effects the solution of the tin and antimony. A mixture of fuming nitric and sulfuric acids might be used to accomplish the same results, but the persulfate mixture is much more efficient.
3. If the solution becomes cool during the first filtration some of the meta-stannic acid may dissolve.
4. If arsenic is present, correction should be made for it.

DETERMINATION OF SULFUR.

METHOD.

Weigh out four 5-g. samples of brass into 250-cc. beakers. Dissolve each in 25 cc. of HNO_3 (sp. gr. 1.42) and boil until the disappearance of red fumes. Add 125 cc. of boiling water and settle for one hour or longer, keeping the temperature just below the boiling point. Filter on double 12.6-cm. closely woven papers, keeping the solutions hot. Wash with boiling water. Discard the meta-stannic acid precipitates, combine the four filtrates in a tall 700-cc. beaker, and add 0.5 g. of Na_2CO_3, and evaporate the solution until syrupy. Cool somewhat, then dilute to the lip with warm water. There should be present a layer about $\frac{1}{4}$ in. (6 mm.) in thickness, composed of basic salts of copper. Electrolyze, using large stationary electrodes, at a current of 4 amperes, or using the Frary solenoid at a current of about 10 amperes. The lead must be removed at the anode as the copper is taken out at the cathode. When copper and lead are out, evaporate the electrolyte to small volume, cover the beaker, add 75 cc. of HCl (sp. gr. 1.20), and boil down to small volume. Add 75 cc. more HCl and evaporate to dryness to dehydrate any silica present. Moisten with about 0.5 cc. of HCl and take up with 20 cc. of hot water. Filter into a small beaker. Heat the filtrate to boiling and add 10 cc. of 5-per-cent $BaCl_2$ solution, drop by drop, with stirring. Allow to settle at least five hours, filter on a small ashless paper, and wash with hot water. Ignite cautiously in a small porcelain or platinum crucible, and then heat to bright redness for 20 minutes. Cool and weigh the $BaSO_4$ and calculate to sulfur.

NOTES.

1. Throughout the entire analysis, the utmost precautions must be taken to prevent contamination by sulfur in any form, H_2SO_4 fumes, H_2S, and SO_2 gases especially. All heating with gas burners must be avoided. Run a blank with each analysis, adding all the reagents and subjecting it to the same operations as the beakers containing the drillings. Subtract the amount of $BaSO_4$ found in the blank from that in the determinations. If this blank amounts to 0.002 g., it is a sign of poor work or impure reagents, and the analysis should be repeated. Wash out all beakers, funnels, etc., with distilled water before using.

2. It is necessary to keep the solution containing the meta-stannic acid hot during filtration. If the solution becomes cool, some of the meta-stannic acid may dissolve.

TENTATIVE METHODS OF CHEMICAL ANALYSIS
OF
BRONZE BEARING METAL.[1]

Serial Designation: B 46 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

GENERAL CONSIDERATIONS.

Practically all of the following methods call for a preliminary separation of tin as meta-stannic acid by means of solution and digestion of the alloy in nitric acid. The meta-stannic acid so obtained is subject to contamination by such alloy constituents as copper and iron and will quantitatively contain such elements as phosphorus, arsenic and vanadium provided the ratio of tin to these elements in the alloy is high enough. In addition to the above drawbacks, tin is not always quantitatively precipitated as meta-stannic acid, particularly when the alloy contains more than 0.25 per cent of iron. In ordinary analyses of material containing but little iron, correction or provision is made for antimony and phosphorus when they are present, and the contaminants and the slight solubility losses are ignored. This procedure results in compensating errors in the determinations of copper and tin; for the impurities make up for dissolved tin while the dissolved tin plates out to a considerable extent with the copper. In umpire analyses, or with alloys high in iron or antimony, the above weaknesses of the method must be taken into account and provision must be made for the complete recovery of all tin, as well as the complete recovery of all contaminating elements carried down with the tin.

A special method is given for the determination of tin in alloys containing considerable phosphorus.

Methods are given for the determination of the impurities: sulfur and antimony.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

DETERMINATION OF COPPER
BY THE
ELECTROLYTIC METHOD.

APPARATUS FOR ELECTROLYSIS.

Electrodes.—The electrodes recommended are of the stationary and not of the rotating type, as the stationary require less of the operator's time and there is less chance for erroneous results to be obtained than with the other kind. Rapid and accurate results are obtained with stationary electrodes made from platinum gauze.

Cathodes.—Platinum cathodes may be formed either from plain or perforated sheets, or from wire gauze, and may be either open or closed cylinders. They should give a depositing surface, counting both sides, of approximately 100 sq. cm. Gauze cathodes are recommended, and are best made from gauze containing approximately 400 meshes per sq. cm. (50 meshes per linear inch). The cathode should be stiffened by doubling the gauze for about 3 mm. at the top and at the bottom of the cylinder. The cylinder should be approximately 30 mm. in diameter and 30 mm. in height. The stem should be made from 1.14-mm. or 1.29-mm. wire, flattened and welded the entire width of the gauze; the height over all should be approximately 130 mm., and the gauze should be sand blasted.

Anodes.—Platinum anodes may be of the spiral type when used in the determination of copper by electrolysis, or in the electrolytic determination of lead when it is present in amounts not over 0.2 per cent. When used in the electrolytic determination of copper and lead together in samples containing 0.2 per cent of lead or over, the anodes should be of wire gauze. Spiral anodes should be made from 1.02-mm. or 1.14-mm. wire formed into a spiral of 7 turns having a height of approximately 51 mm. and a diameter of 16 mm., the length over all being approximately 145 mm. Platinum gauze used in making anodes should contain approximately 400 meshes per sq. cm. (50 meshes per linear inch). The gauze should be formed into closed cylinders approximately 12 mm. in diameter and 30 mm. in height. The cylinders should be stiffened by doubling the gauze for about 3 mm. at the top and at the bottom. The stem should be made from 1.02-mm. or 1.29-mm. wire, flattened and welded the entire width of the gauze; the height over all should be approximately 130 mm., and the gauze should be sand blasted.

METHOD.

In a 150-cc. beaker, dissolve 1 g. of the bronze in 10 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, boil until the oxides of nitrogen are expelled, add 50 cc. of hot distilled water, and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on double 7-cm. ashless papers, being careful to keep the solution hot throughout the process of filtration, and receiving the filtrate in a 200-cc. beaker of the tall type used in electrolysis. Wash with boiling hot water. Retain the papers containing the precipitate for subsequent use in the tin determination.

Add to the filtrate, 5 cc. of H_2SO_4 (sp. gr. 1.84), and determine copper by electrolysis, retaining the electrolyte, after the removal of the copper, for the subsequent determination of zinc. See the "Determination of Copper by the Electrolytic Method," Standard Methods of Chemical Analysis of Manganese Bronze (Serial Designation: B 27) of the American Society for Testing Materials.[1]

NOTES.

Copper, zinc, and tin are conveniently determined on the same sample, tin being first removed, and any zinc tested for after copper has been deposited by electrolysis.

If the solution becomes cool during the first filtration, some of the meta-stannic acid (H_2SnO_3) may dissolve.

DETERMINATION OF TIN.

(FOR SAMPLES FREE FROM PHOSPHORUS)

METHOD.

See the "Determination of Copper by the Electrolytic Method."

Use the papers containing the meta-stannic acid which was filtered off in the "Determination of Copper by the Electrolytic Method." Ignite the papers with the precipitate while moist in a porcelain or platinum crucible, slowly at first, and finally at the full heat of the burner. If the precipitate weighs more than 20 mg., heat to constant weight, using a blast lamp. Weigh as SnO_2, and calculate to Sn.

NOTES.

1. This method is not accurate for alloys which contain phosphorus, or which contain over 0.25 per cent of iron.

2. The ignited tin oxide contains small amounts of iron and copper as well as any phosphorus, antimony or arsenic which may be present in the alloy. Qualitative tests should be made for phosphorus, antimony and arsenic. In the absence of antimony and arsenic the following "Qualitative Test for Phosphorus" is here made use of to detect phosphorus and to estimate its amount, if any is found.

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[1] 1921 Book of A.S.T.M. Standards.

QUALITATIVE TEST FOR PHOSPHORUS.

SOLUTIONS REQUIRED.

Ferric Chloride.—Dissolve 25 g. of ferric chloride in 100 cc. of distilled water, and add 25 cc. of HCl (sp. gr. 1.20).

METHOD.

Dip a piece of the alloy into a few cubic centimeters of ferric chloride for about ten seconds, and rinse it in running water. Alloys containing phosphorus are darkened noticeably where they have been dipped; alloys containing over 0.25 per cent of phosphorus are rendered almost black by this test.

In alloys containing up to 0.20 per cent of phosphorus, a correction for its presence in the ignited tin oxide may be made according to the following empirical method. From the phosphorus content of the alloy, which has been determined on a separate sample, calculate the weight of P_2O_5 and subtract two-thirds of this weight from the weight of the ignited tin oxide containing phosphorus. The remainder is considered as pure SnO_2. The factor for converting phosphorus to $\frac{2}{3} \times P_2O_5$ is 152.6 per cent, or approximately $1\frac{1}{2}$ times the phosphorus content of the sample.

If the alloy contains over 0.20 per cent of phosphorus, a special method for the determination of tin should be used.

In alloys which contain over 0.25 per cent of iron, use the method for the "Determination of Tin" in the Standard Methods of Chemical Analysis of Manganese Bronze (Serial Designation: B 27) of the American Society for Testing Materials.[1]

DETERMINATION OF TIN.

(FOR SAMPLES CONTAINING PHOSPHORUS.)

SOLUTIONS REQUIRED.

Yellow Ammonium Sulfide.—Saturate 150 cc. of NH_4OH (sp. gr. 0.90) with H_2S gas, and then add 50 cc. more of NH_4OH. Dissolve in this solution 3 or 4 g. of sulfur flour, and about 1 g. of NH_4Cl. Make up this solution fresh, and filter immediately before using.

Dilute Yellow Ammonium Sulfide for Washing.—Mix 20 cc. of yellow ammonium sulfide, prepared as above, and 400 cc. of distilled water.

Ammonium Acetate for Washing.—Dissolve 10 g. of ammonium acetate in 300 cc. of distilled water, make slightly acid with acetic acid and saturate with H_2S gas.

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[1] 1921 Book of A.S.T.M. Standards.

METHOD.

See the "Determination of Copper by the Electrolytic Method."

Use the papers containing the freshly filtered meta-stannic acid which was filtered off in the "Determination of Copper by the Electrolytic Method." Transfer the papers with the precipitate to a 150-cc. beaker, and cover with 40 to 50 cc. of yellow ammonium sulfide. Warm for about 15 minutes, or until the meta-stannic acid has dissolved. Filter and wash thoroughly with dilute yellow ammonium sulfide. Acidify the combined filtrate and washings cautiously with 50-per-cent acetic acid. Warm, and allow the precipitated tin sulfide and sulfur to settle. Filter on double papers and wash with ammonium acetate solution. Dry the precipitate, and place it with the papers in a porcelain crucible which projects part way through a hole in a piece of asbestos board. Heat slowly until the free sulfur has been driven off, but without allowing the sulfur to burn. When the sulfur has been expelled, place the crucible on a triangle and ignite slowly at first, and finally at the full heat of the burner. If the precipitate weighs more than 20 mg., heat to constant weight, using a blast lamp. Weigh as SnO_2, and calculate to Sn.

Accuracy.—Duplicate determinations should check within 0.06 per cent of tin.

NOTES.

1. The ignited tin oxide will contain any arsenic or antimony that was present in the sample.

2. During the ignition, if the sulfur is allowed to burn, some tin sulfate may be formed, causing high results. On the other hand, low results may be caused by too high heat, which causes spattering and volatilizes some tin sulfide.

DETERMINATION OF LEAD
BY THE
ELECTROLYTIC METHOD.

APPARATUS.

Electrodes and other apparatus used in electrolysis; see the "Determination of Copper by the Electrolytic Method."

METHOD.

In a 150-cc. beaker, dissolve 1 g. of the bronze in 10 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, boil until the oxides of nitrogen are expelled; add 50 cc. of boiling hot distilled water and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on double 7-cm. ashless papers, being careful to keep the solution hot throughout the process of filtration. Wash with boiling hot water. Add to the filtrate 9 cc. of HNO_3 (sp. gr. 1.42) and dilute to about 150 cc. with distilled water. Insert a sand-blasted platinum gauze electrode in the anode terminal; this electrode may be one of the type used as cathode in the "Determination of Copper by the Electrolytic Method," or it may be one of the sand-blasted gauze anodes therein described. Insert in the cathode terminal one of the electrodes used as anode in the "Determination of Copper by the Electrolytic Method." Cover with a pair of split watch glasses and electrolyze. For each solution use a current of 2 amperes at 10 volts continued for about 2 hours. Wash down the cover glasses, electrodes, and sides of the beakers, raising the level of the liquid 5 or 6 mm., and continue the electrolysis for 15 minutes. If no darkening of the newly exposed surface of the platinum can be detected, the lead has been entirely deposited. If the newly exposed surface of the platinum is darkened, continue the electrolysis until no such darkening can be detected when the current has been continued for 15 minutes after the level of the liquid has been raised.

When the lead has been entirely deposited, remove the anode quickly and rinse it in distilled water and then in alcohol, and dry in an oven at 210° C. for 30 minutes. Weigh as PbO_2, using the factor for lead 0.8643 instead of the theoretical value.

NOTES.

1. It is impossible to remove the tin quantitatively as H_2SnO_3 in the case of alloys containing over 0.25 per cent of iron, and traces of tin are sometimes found in the PbO_2 deposit.

2. In this and in the following method, a slight amount of lead may be retained by the H_2SnO_3. This should be recovered in very accurate work, but is neglected in a routine analysis.

3. *Samples for Analysis.*—When lead is less than 0.10 per cent, a 5 or 10-g. sample is taken. The 5-g. sample should be dissolved in 25 cc. of HNO_3. The 10-g. sample should be dissolved in 45 cc. of HNO_3. When the lead content is greater than 15 per cent, dissolve the sample in HNO_3 as described under Method, transfer the solution to a graduated flask and choose aliquot portions for analysis in order not to exceed the above mentioned limit of lead to be deposited on the anode as PbO_2. The lead peroxide will tend to flake off the electrode when the amount deposited becomes excessive.

DETERMINATION OF LEAD
BY THE
"LEAD-ACID" METHOD.
(OPTIONAL.)

SOLUTIONS REQUIRED.

"*Lead-Acid.*"—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 180 cc. of distilled water. Dissolve 1 g. of lead acetate, c. p., in 300 cc. of distilled water and add this to the hot solution with stirring. Let stand at least 24 hours, and siphon through a thick asbestos filter.

Dilute Alcohol for Washing.—Mix equal parts of denatured alcohol and distilled water.

METHOD.

In a 150-cc. beaker, dissolve 1 g. of the bronze in 10 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, boil until the oxides of nitrogen are expelled, add 50 cc. of boiling hot distilled water, and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on double 7-cm. ashless papers, being careful to keep the solution hot throughout the process of filtration. Wash with boiling hot water. Add 40 cc. of lead-acid and evaporate until copious fumes of H_2SO_4 are evolved. Cool, add 35 cc. of distilled water to dissolve the salts. Heat to boiling and allow to cool and settle for 5 hours, or over night, if convenient. Filter on a weighed Gooch crucible and wash with lead-acid. Wash out the lead-acid with dilute alcohol, set the Gooch crucible inside a porcelain crucible, ignite for five minutes at the full heat of a Tirrell burner, cool and weigh as $PbSO_4$, and calculate to Pb.

NOTES.

1. Copper and lead may be determined on the same samples if so desired. In such a case, after filtering off the lead sulfate and washing with lead-acid, and before washing with dilute alcohol, remove the filtrate, add 3 cc. of HNO_3 (sp. gr. 1.42), dilute to 120 cc. and determine copper by electrolysis. See the "Determination of Copper by the Electrolytic Method."

2. Copper and lead may also be determined simultaneously by the electrolytic method. See the Standard Methods of Chemical Analysis of Manganese Bronze (Serial Designation: B 27) of the American Society for Testing Materials.[1]

DETERMINATION OF IRON.

SOLUTIONS REQUIRED.

Yellow Ammonium Sulfide.—Saturate 150 cc. of NH_4OH (sp. gr. 0.90) with hydrogen sulfide gas, and then add 50 cc. more of NH_4OH. Dissolve in this solution 3 or 4 g. of sulfur flour, and about 1 g. of NH_4Cl. Make up this solution fresh, and filter it immediately before use.

Dilute Yellow Ammonium Sulfide for Washing.—Mix 20 cc. of yellow ammonium sulfide, prepared as above, and 400 cc. of distilled water.

Other Solutions.—See the "Determination of Iron" in the Tentative Methods of Chemical Analysis of Brass Ingots and Sand

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[1] 1921 Book of A.S.T.M. Standards.

Castings (Serial Designation : B 45 – 22 T) of the American Society for Testing Materials.[1]

METHOD.

In a 150-cc. beaker, dissolve 1 g. of bronze in 10 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, boil until the oxides of nitrogen are expelled, add 50 cc. of boiling water, and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on double 7-cm. papers, keeping the solution hot, and wash with boiling hot water. Retain both the filtrate and the precipitate. Transfer the papers with the precipitate to a 150-cc. beaker, and cover them with 40 to 50 cc. of yellow ammonium sulfide. Warm about 15 minutes, or until the meta-stannic acid is dissolved. Filter and wash thoroughly with hot, dilute yellow ammonium sulfide.

Dissolve the small black residue on the filter with hot dilute HCl, receiving the solution in a small beaker. Add 5 cc. of HNO_3 (sp. gr. 1.42) and boil to oxidize sulfur and iron. Add this small solution to the original filtrate from the meta-stannic acid. Add about 5 g. of NH_4Cl, then NH_4OH (sp. gr. 0.90) and proceed as in the "Determination of Iron" in the Tentative Methods of Chemical Analysis of Brass Ingots and Sand Castings (Serial Designation : B 45 – 22 T) of the American Society for Testing Materials.[1]

DETERMINATION OF NICKEL
BY THE
DIMETHYLGLYOXIME METHOD.

SOLUTIONS REQUIRED.

Dimethylglyoxime Solution.—Dissolve 5 g. of dimethylglyoxime in 500 cc. of grain alcohol, and filter before using.

Sodium Potassium Tartrate Solution.—Dissolve 200 g. of the salt in 1 liter of distilled water.

Dilute Ammonia for Washing.—Solution containing 10 cc. of NH_4OH (sp. gr. 0.90) per liter of water.

METHOD.

In a 200-cc. electrolytic beaker, dissolve a 1-g. sample exactly as in the "Determination of Copper by the Electrolytic Method" and remove the copper by electrolysis. Evaporate the solution to about 100 cc., filter, add about 1 g. of NH_4Cl, then 10 cc. of sodium potassium tartrate solution, and nearly neutralize with NH_4OH (sp. gr. 0.90).

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[1] See p. 664.

Heat nearly to boiling, add 5 cc. of dimethylglyoxime solution for each 0.01 g. or fraction of nickel present and then NH_4OH in slight excess. Let stand at least 30 minutes on the steam-bath, filter and wash with dilute ammonia solution. For accurate work, the precipitate should be dissolved in hot HCl (1 : 1) and reprecipitated as before. Filter on a weighed Gooch crucible, wash with dilute ammonia solution, and then with hot water; dry at 110 to 120° C. for about two hours and weigh as the glyoxime salt which contains 20.31 per cent of nickel. If it is preferred, instead of by weighing the glyoxime salt, the nickel can be determined electrolytically as follows: Dissolve the red precipitate of nickel glyoxime in hot HCl (1 : 1), add 10 cc. of H_2SO_4 (1 : 1) and evaporate to strong fumes. Dilute, neutralize with NH_4OH (sp. gr. 0.90), and add 20 cc. in excess. The final volume should be about 150 cc. Electrolyze with a current of 0.3 ampere per solution. Test the solution for completion of deposition with fresh H_2S water as is done in the "Determination of Copper by the Electrolytic Method." Remove the cathode, wash with water and dry with alcohol as in the "Determination of Copper by the Electrolytic Method." Weigh the deposit as metallic nickel.

DETERMINATION OF ZINC.

Method.

See the "Determination of Copper by the Electrolytic Method."

After the copper has been completely deposited by electrolysis, quickly remove the cathode and wash it thoroughly with distilled water, catching the washing in the beaker containing the electrolyte. Heat the solution and saturate with H_2S gas. Filter off any precipitate, and boil the solution to expel H_2S. Make the solution barely alkaline with NH_4OH, and add 25 cc. of 85-per-cent formic acid. Dilute the solution with distilled water to 300 cc., heat to boiling, and saturate with H_2S gas. Filter, wash with hot water and dissolve the precipitate with hot HCl (1 : 1) and transfer the solution to a weighed platinum or porcelain dish or crucible. Add a few drops of H_2SO_4 (sp. gr. 1.84) and evaporate the solution until copious fumes escape. If the solution is not clear and colorless, cool, add a few cubic centimeters of HNO_3 (sp. gr. 1.42) and again evaporate the solution until fumes of H_2SO_4 come off freely. Repeat the treatment with HNO_3, if necessary, until the organic matter is destroyed, and the solution is colorless. Remove the excess of H_2SO_4 by heating the dish cautiously, and finally heat to dull redness. Weigh as $ZnSO_4$ and calculate to Zn.

DETERMINATION OF PHOSPHORUS
BY THE
ALKALIMETRIC METHOD.

SOLUTIONS REQUIRED.

Nitric Acid for Dissolving.—Mix 1000 cc. of HNO_3 (sp. gr. 1.42) and 1200 cc. of distilled water.

Nitric Acid for Washing.—Mix 20 cc. of HNO_3 (sp. gr. 1.42) and 1000 cc. of distilled water.

Ammonium Molybdate Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of NH_4OH (sp. gr. 0.90), filter and add 60 cc. of HNO_3 (sp. gr. 1.42).

Ammonium Molybdate Solution No. 2.—Mix 400 cc. of HNO_3 (sp. gr. 1.42) and 960 cc. of distilled water.

When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water and let stand at least 24 hours before using.

Potassium Nitrate, 1-per-cent Solution—Dissolve 10 g. of potassium nitrate in 1000 cc. of distilled water.

Phenolphthalein Indicator.—Dissolve 0.2 g. in 50 cc. of 95-per-cent ethyl alcohol and 50 cc. of distilled water.

Standard Sodium Hydroxide.—Dissolve 3.3 g. of purified NaOH in 1000 cc. of distilled water, add a slight excess of 1-per-cent solution of barium hydroxide, let stand for 24 hours, decant the liquid, and standardize it against a steel of known phosphorus content as determined by the molybdate-magnesia method, so that 1 cc. will be equivalent to 0.01 per cent of phosphorus on the basis of a 1-g. sample (see Notes). Protect the solution from carbon dioxide with a soda-lime tube.

Ferric Chloride.—Dissolve 100 g. of ferric chloride (phosphorus free) in 100 cc. of distilled water.

Standard Nitric Acid.—Mix 5 cc. of HNO_3 (sp. gr. 1.42) and 1000 cc. of distilled water. Titrate the solution against standardized NaOH, using phenolphthalein as indicator, and make it equivalent to the sodium hydroxide by adding distilled water.

METHOD.

In a 400-cc. beaker, dissolve a 1-g. sample in 10 cc. of HNO_3 (sp. gr. 1.42) and heat until brown fumes are driven off; then add 15 cc. of HCl (sp. gr. 1.20) and evaporate to dryness. Add 10 cc. of HCl (sp. gr. 1.20) and again evaporate to dryness, but do not bake.

Add 15 cc. of HCl (sp. gr. 1.20) and heat to solution; dilute with 50 cc. of distilled water and bring to a boil. Take off the hot plate and wash down the cover glass and sides of the beaker, add 20-mesh c. p. zinc, 2 or 3 g. at a time until the solution becomes colorless, that is until all the copper, tin and lead are precipitated. Filter, receiving the filtrate in the 400-cc. beaker, and wash well with hot water.

Add 3 cc. of the ferric chloride solution to this filtrate and make faintly ammoniacal; bring to a boil, let settle and filter. Dissolve this precipitate in hot dilute HCl and again make ammoniacal; heat to boiling, let settle and filter, washing well with hot water.

Dissolve this precipitate in as small a quantity of hot dilute HNO_3 as possible, receiving the solution in a 300-cc. Erlenmeyer flask; wash filter free of iron with hot dilute HNO_3 and hot distilled water. Evaporate to about 15 cc., cool, make ammoniacal, then neutralize with HNO_3 (sp. gr. 1.42) and add 5 cc. in excess. Cool to 80° C., and add 60 cc. of the ammonium molybdate solution. Let stand one minute, then shake three minutes and let settle. Filter on an 11-cm. filter (using a small quantity of paper pulp on the filter) and wash free of iron with 2-per-cent nitric acid wash, then free of acid with the 1-per-cent potassium nitrate solution.

Place the paper in the thoroughly washed acid-free flask in which the original precipitation was made, add 25 cc. of distilled water and an excess of the standard sodium hydroxide solution. By using a long glass rod, the paper can be pulped and the yellow precipitate dissolved in a very few seconds. Wash off the rod and the sides of the flask and add a few drops of the phenolphthalein solution and titrate the excess of standard NaOH with the standard HNO_3. The strength of the standard NaOH and the standard HNO_3 in terms of phosphorus can be determined by using a standard steel or preferably a standard phosphor bronze in which the phosphorus has been determined by the molybdate-magnesia method.

Accuracy.—Duplicate determinations should check within 0.01 per cent of phosphorus.

NOTES.

1. The ammonium molybdate solution should be kept in a cool place and should always be filtered before using.

2. All distilled water used in titration should be freed from carbon dioxide by boiling or otherwise.

3. Bureau of Standards Standard Steel No. 19 (*a*) or a bronze of known phosphorus content are recommended as suitable materials for standardization of the sodium hydroxide solution.

4. (Gravimetric method, optional.) It is considered by some that more accurate

results can be obtained by a gravimetric determination of phosphorus as $Mg_2P_2O_7$. This can be carried out by dissolving the yellow molybdate precipitate in 20 cc. of NH_4OH (1 : 1) to which has been added 2 g. of citric acid, precipitating with magnesia mixture, and proceeding as usual, finally weighing as $Mg_2P_2O_7$.

5. Determination of phosphorus by the ferric alum method is optional. See the Standard Methods of Chemical Analysis of Gun Metal (Serial Designation: B 28) of the American Society for Testing Materials.[1]

DETERMINATION OF ANTIMONY
BY THE
VOLUMETRIC METHOD.

SOLUTIONS REQUIRED.

Potassium Permanganate.—Dissolve 0.3 g. of potassium permanganate in 1000 cc. of distilled water. Standardize by dissolving 25 mg. of pure antimony in 15 cc. of boiling H_2SO_4 and proceeding according to the method from this point.

METHOD.

In a 250-cc. beaker, dissolve 5 g. of bronze in 25 cc. of HNO_3 (sp. gr. 1.42). When the action has ceased, boil until the oxides of nitrogen are expelled, add 125 cc. of boiling water and allow to stand and settle for one hour or longer, keeping the temperature just below the boiling point. Filter on double 9-cm. closely woven papers, keeping the solution hot. Wash with boiling water. Discard the filtrate.

Transfer the papers containing the tin and antimony to a 350-cc. Erlenmeyer flask and add 25 cc. of HNO_3 (sp. gr. 1.42), 5 g. of ammonium persulfate, and 15 cc. of H_2SO_4 (sp. gr. 1.84). Boil to strong fumes of SO_3. If the solution is brown, *cool* and add 5 cc. of HNO_3 (sp. gr. 1.42) and a little more (1 g. or less) persulfate, if necessary, and boil again to strong fumes of SO_3. When the solution is colorless, cool, add 20 cc. of distilled water, 20 cc. of HCl (sp. gr. 1.20) and 1 g. of sodium sulfite. Boil gently for 10 minutes to expel SO_2 completely. Dilute with 200 cc. of distilled water and cool to 10 to 12° C. in ice or under running water.

Titrate with standard permanganate solution until the appearance of a decided permanent pink color.

NOTES.

1. In alloys containing a large excess of tin, the antimony is precipitated quantitatively with the meta-stannic acid.

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[1] 1921 Book of A.S.T.M. Standards.

2. Ammonium persulfate and HNO_3 are used to destroy the filter paper, and subsequent boiling with H_2SO_4 effects the solution of the tin and antimony. A mixture of fuming HNO_3 and H_2SO_4 might be used to accomplish the same results, but the persulfate mixture is much more efficient.

3. If the solution becomes cool during the first filtration, some of the meta-stannic acid may dissolve.

4. If arsenic is present, correction should be made for it.

DETERMINATION OF SULFUR.

METHOD.

Weigh out four 5-g. samples of bronze into 250-cc. beakers. Dissolve each in 25 cc. of HNO_3 (sp. gr. 1.42) and boil until the disappearance of red fumes. Add 125 cc. of boiling water and allow to settle for one hour or longer, keeping the temperature just below the boiling point. Filter on double 12.5-cm. closely woven papers, keeping the solution hot. Wash with boiling water. Discard the meta-stannic acid precipitates, combine the four filtrates in a tall 700-cc. beaker and add 0.5 g. of sodium carbonate, and evaporate the solution until syrupy. Cool somewhat, then dilute to the lip with warm water. There should be present a layer about 6 mm. in thickness, composed of basic salts of copper. Electrolyze, using large stationary electrodes, at a current of 4 amperes, or using the Frary solenoid at a current of about 10 amperes. The lead must be removed at the anode as the copper is taken out at the cathode. When copper and lead are out, evaporate the electrolyte to small volume, cover the beaker, add 75 cc. of HCl (sp. gr. 1.20) and boil down to small volume. Add 75 cc. more HCl and evaporate to dryness to dehydrate any silica present. Moisten with about 0.5 cc. of HCl and take up with 20 cc. of hot water. Filter into a small beaker. Heat the filtrate to boiling and add 10 cc. of 5-per-cent $BaCl_2$ solution, drop by drop, with stirring. Allow to settle at least five hours, filter on a small ashless paper, and wash with hot water. Ignite cautiously in a small porcelain or platinum crucible, and then heat to a bright redness for 20 minutes. Cool and weigh the $BaSO_4$ and calculate to sulfur.

NOTES.

1. Throughout the entire analysis, the utmost precautions must be taken to prevent contamination by sulfur in any form, H_2SO_4 fumes, H_2S, and SO_2 gases especially. All heating with gas burners must be avoided. Run a blank with each analysis, adding all the reagents and subjecting it to the same operations as the beakers containing the drillings. Subtract the amount of $BaSO_4$ found in the blank from that in the determinations. If this blank amounts to 0.002 g., it is a sign of poor work or impure reagents and the analysis should be repeated. Wash out all beakers, funnels, etc., with distilled water before using.

2. It is necessary to keep the solution containing the meta-stannic acid hot during filtration. If the solution becomes cool, some of the meta-stannic acid may dissolve.

DETERMINATION OF ARSENIC.

SOLUTIONS REQUIRED.

Ammonium Carbonate.—Dissolve 150 g. of ammonium carbonate in one liter of distilled water.

METHOD.

Dissolve the sample (5.00 to 10.00 g.) in a 100-cc. beaker in 10 cc. of HNO_3 (sp. gr. 1.42) and 30 cc. of HCl (sp. gr. 1.19). When solution is complete, cool, add 35 cc. of H_2SO_4 (sp. gr. 1.84) evaporate to the appearance of copious fumes of H_2SO_4, and continue the fuming for from ten to fifteen minutes. Cool, take up in HCl (sp. gr. 1.19), transfer to an 800-cc. flask having a two-hole stopper with separatory funnel and outlet tube connecting with a vertical condenser outside. (The part of the outlet tube within the distilling flask should have a steam outlet hole about 1 cm. from the open end.) Rinse the beaker with HCl (sp. gr. 1.19) and dilute the solution with the acid to make a total volume of 350 to 450 cc. Add 10 g. of cuprous chloride (Cu_2Cl_2), connect the flask with the condenser, and gradually raise the contents of the flask to boiling. Catch the distillate in a tall 400-cc. beaker containing 100 cc. of cold water. The end of the condenser should extend several millimeters into the water in the beaker and the beaker should be surrounded with ice water in order to avoid any possible volatilization of arsenious chloride. After about 100 cc. of distillate has passed over, remove the flame from the distilling flask, pour 3 to 5 cc. of hypophosphorus acid through the separatory funnel into the distilling flask, and redistill as before, catching the distillate in the same beaker. The volume of the second distillate should be 50 to 100 cc. Pass a rapid current of H_2S through the distillate for one hour, allow to settle, and filter on a weighed Gooch crucible. Wash twice with HCl (1 : 1), four times with cold water, three times with alcohol, and four times with CS_2. Dry at 110° C. for 10 minutes, and weigh after cooling. Dissolve the As_2S_3 with $(NH_4)_2CO_3$ solution, wash thoroughly with water, dry for 30 minutes at 110° C. and reweigh after cooling. The difference in weights multiplied by 0.609 gives the weight of arsenic.

NOTE.

1. Blank determinations should be made on the reagents carried along as in the method and the proper corrections made.

TENTATIVE SPECIFICATIONS
FOR
QUICKLIME FOR STRUCTURAL PURPOSES.[1]

Serial Designation: C 5 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

I. REQUIREMENTS.

Requirements. 1. The quicklime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

	CALCIUM LIME.	MAGNESIAN LIME.
Calcium oxide, minimum, per cent	75	..
Magnesium oxide, minimum, per cent	..	20
Calcium and magnesium oxides, minimum, per cent	95	95
Silica, alumina, and oxide of iron, maximum, per cent	5	5
Carbon dioxide, maximum, per cent		
(*a*) If sample is taken at the kiln	3	3
(*b*) If sample is taken at any other place	10	10

Percentage of Waste. 2. When tested in accordance with the method given below, quicklime shall contain not more than 3 per cent by weight of waste.

Density. 3. (Specification to be supplied by the committee.)

II. METHODS OF TEST.

Chemical Analysis. 4. The chemical analysis of the lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 – 22 T) of the American Society for Testing Materials.[2]

Percentage of Waste. 5. An average $2\frac{1}{2}$-kg. (5-lb.) sample shall be put in a box and slaked by an experienced operator with sufficient water to produce the maximum quantity of lime putty, care being taken to avoid "burning" or "drowning" the lime. It shall be allowed to stand for 24 hours and then washed through a No. 20 sieve by a stream of water having a moderate pressure. No material shall be rubbed through the sieve. The sample of lump lime taken for this test shall be broken so as to all pass a No. 1 sieve and be retained on a No. 3 sieve. Pulverized lime shall be tested as received.

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[1] These tentative specifications are intended to supersede the Standard Specifications for Quicklime. The Standard Specifications, which were last published under the Serial Designation: C 5-15, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

[2] See p. 715.

Apparent Density.

6. (Specification to be supplied by the committee.)

III. SAMPLING, RETESTING, PACKING AND MARKING.

Sampling, Retesting, Packing, Marking.

7. The sampling, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 – 22 T) of the American Society for Testing Materials.[1]

APPENDIX.

Quicklime can never be used as such for structural purposes; it must always be slaked first. Since the method of slaking is an important factor in determining the quality of the finished product, the following directions are given, not as a part of the specifications, but as information for the further protection of the purchaser.

PREPARATION OF LIME PUTTY.

Directions for Slaking.

1. (*a*) *Introduction.*—Different kinds of lime vary considerably in the way in which they behave with water. A little supervision over the operation of slaking will amply pay for itself by insuring the production of the greatest possible quantity and the best possible quality of putty. To find out how to slake a new lot of lime, it is safest to try a little of it and see how it works. Since different lots of the same brand of lime vary somewhat, and since the weather conditions at the time have a decided influence, it is wise to try a sample from each lot used, whether familiar with the brand or not.

(*b*) *Classification of Limes.*—In a bucket, put two or three lumps of lime about the size of one's fist, or, in the case of granular lime, an equivalent amount. Add enough water to just barely cover the lime, and note how long it takes for slaking to begin. Slaking has begun when pieces split off from the lumps or when the lumps crumble. Water of the same temperature should be used for test and field practice.

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[1] See p. 728.

If slaking begins in less than five minutes, the lime is quick slaking; from five to thirty minutes, medium slaking; over thirty minutes, slow slaking.

(*c*) *Directions for Slaking.*—For quick-slaking lime, always add the lime to the water, not the water to the lime. Have enough water at first to cover all the lime completely. Have a plentiful supply of water available for immediate use—a hose throwing a good stream, if possible. Watch the lime constantly. At the slightest appearance of escaping steam, hoe thoroughly and quickly, and add enough water to stop the steaming. Do not be afraid of using too much water with this kind of lime.

For medium-slaking lime, add the water to the lime. Add enough water so that the lime is about half submerged. Hoe occasionally if steam starts to escape. Add a little water now and then if necessary to prevent the putty from becoming dry and crumbly. Be careful not to add any more water than required, and not too much at a time.

For slow-slaking lime, add enough water to the lime to moisten it thoroughly. Let it stand until the reaction has started. Cautiously add more water, a little at a time, taking care that the mass is not cooled by the fresh water. Do not hoe until the slaking is practically complete. If the weather is very cold, it is preferable to use hot water but if this is not available, the mortar box may be covered in some way to keep the heat in.

Preparation of Putty for Use.

2. (*a*) *White Coat.*—After the action has ceased, run off the putty through a No. 10 sieve and store for a minimum of two weeks.

(*b*) *Base Coats.*—After the action has ceased, run off the putty through a No. 8 sieve. Add sand up to equal parts by weight, all of the hair required, and store for a minimum of two weeks.

(*c*) *Masons' Mortar.*—After the action has ceased, add part or all of the sand required, and store for a minimum of 24 hours.

TENTATIVE SPECIFICATIONS
FOR
HYDRATED LIME FOR STRUCTURAL PURPOSES.[1]

Serial Designation: C 6-22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1917; REVISED, 1919, 1921, 1922.

1. These specifications cover two classes of hydrated lime: namely, masons' hydrate and finishing hydrate.

Uses.

2. (*a*) Masons' hydrated lime may be used for scratch or brown coat of plaster, for stucco, for mortars, and for addition to portland-cement concrete.

(*b*) Finishing hydrated lime may be used for any of the purposes enumerated in Paragraph (*a*) for masons' hydrated lime, and in addition it may be used as an ingredient of the final or white coat of plaster.

I. REQUIREMENTS.

Masons' Hydrate.

3. Masons' hydrated lime shall conform to the chemical and physical requirements herein specified except that for plasticity, specified in Section 9.

Finishing Hydrate.

4. Finishing hydrated lime shall conform to all chemical and physical requirements herein specified including that for plasticity, specified in Section 9.

Chemical Properties.

5. (*a*) *Carbon Dioxide.*—Carbon dioxide in the sample shall not exceed 5 per cent if the sample is taken at the place of manufacture, or 7 per cent if the sample is taken at any other place. The percentages in both cases are based on the non-volatile portion.

(*b*) *Calcium and Magnesium Oxides.*—Calcium and magnesium oxides shall constitute not less than 95 per cent of the non-volatile portion.

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[1] These tentative specifications are intended to supersede the Standard Specifications for Hydrated Lime. The Standard Specifications, which were last published under the Serial Designation: C 6-15, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

Fineness. 6. A 100-g. sample shall leave a residue of not more than 0.5 per cent on a No. 30 sieve, and not more than 15 per cent on a No. 200 sieve.

Constancy of Volume. 7. A pat of mortar, covered with a skim coat of neat paste, shall be subjected to the action of steam. If the steam has no visible effect on the pat, the sample shall be reported as being "sound." If the pat disintegrates, the sample shall be reported "unsound," and the shipment rejected. If the sample cracks, pops, or shows other minor defects, it shall not be reported as either sound or unsound, but its behavior shall be noted.

Tensile Strength. 8. When tested in the form of a mortar composed of 1 part by weight of the sample and 3 parts by weight of standard Ottawa sand, the mortar shall show a tensile strength of not less than 15 lb. per sq. in. at 7 days.

Plasticity. 9. Finishing hydrated lime shall have a plasticity figure of not less than 200, when tested in accordance with Section 15.

III. METHODS OF TEST.

Chemical Analysis. 10. The chemical analysis of the hydrated lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 - 22 T) of the American Society for Testing Materials.[1]

Fineness. 11. Fineness[2] of hydrated lime shall be determined as follows:

One hundred grams of the sample as received shall be placed on a No. 30 sieve which shall be nested above a No. 200 sieve. The material shall be washed by means of a stream of water from a faucet (Note 1). The washing shall be continued until the water coming through the sieve is clear. The residue upon the No. 30 sieve shall be dried to constant weight in an atmosphere free from carbon dioxide in a drying oven whose temperature is maintained between 100 and 120° C. The weight of this residue shall be calculated as percentage of the original sample.

The material which has passed the No. 30 sieve and remained on the No. 200 sieve shall be then washed through the latter as above described. The residue on this sieve shall be treated in the same manner as described above for that retained on the No. 30 sieve and the percentage retained added to the percentage of residue on the No. 30 sieve. The sum of these two shall be reported as the percentage of residue on the No. 200 sieve.

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[1] See p. 715.

[2] Specifications for U. S. Standard Sieve Series in a publication now being prepared to supersede Bureau of Standards *Circular No. 39.*

NOTE 1.—A small piece of rubber tubing attached to a water faucet will be found convenient. The velocity of the stream of water may be increased by pinching the tubing, but the velocity should not be sufficient to cause any danger of splashing the sample over the sides of the sieve.

Constancy of Volume.

12. Constancy of volume shall be determined as follows:

To 20 g. of the sample, 100 g. of standard Ottawa sand shall be added, mixed thoroughly and enough water added to the mixture to make a good plastic mortar of a rather dry consistency. This shall be spread out on a clean glass plate to form a layer of about 0.5 cm. ($\frac{1}{4}$ in.) thick by about 10 cm. (4 in.) square. The pat shall be of even thickness throughout and not tapering at the edges. If the mortar is too dry to work well, more water may be added. This pat shall be placed in a closet for 24 hours to set. The temperature in the closet shall be between 18 and 24° C. (65 and 75° F.) and there shall be free circulation of air in the closet but no direct draft shall be permitted to hit the pat. At the end of 24 hours the pat shall be removed from the closet and soaked in water until a film of water stands unabsorbed on the surface of the pat. The pat shall be examined carefully for cracks. If any are present, too much water has been used in making the pat and it should be discarded and a new one made.

Twenty grams of the sample shall be mixed with enough water to form a thick cream. This shall be spread out in a thin layer on the surface of the pat. It shall be allowed to stand for 15 minutes to permit possible air bubbles to form. It shall be troweled to an even surface, making this skim coat as thin as possible without allowing the sand to show through. The pat shall be put back in the closet for another 24 hours for the skim coat to set. It shall be examined carefully to make sure there are no cracks or pops. A vessel shall be provided partially filled with cold water and having a perforated cover. The pat shall be suspended in this vessel in such a way that the water can boil without touching it. The water shall be brought gradually to boiling and kept boiling gently for 5 hours, the pat being surrounded by steam during this time. The water shall then be permitted to cool for at least 12 hours before the cover is removed from the vessel. The pat shall then be removed and examined for cracking, popping, or disintegration.

Tensile Strength.

13. In a suitable vessel, 200 g. of the sample shall be mixed with 600 g. of standard Ottawa sand. Sufficient water shall be added to bring the mixture to the proper consistency which shall be determined as follows:

A clean and well-oiled cylindrical mold, 5 cm. (2 in.) in diameter by 10 cm. (4 in.) high, shall be prepared and mounted on a glass plate. This mold shall be filled with the lime mortar, struck off level and the mold removed immediately by raising it vertically. The mortar is of the proper consistency when the final height of the cylinder, after the mold is removed, is 9 cm. (3½ in.).

The mixture having been brought to the proper consistency, it shall be molded to form six briquettes. These briquettes shall be of the form and size specified in Section 50 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.[1] After the molds have been filled with the mortar, the whole shall be placed on edge in a damp closet and permitted to stand over night. They shall then be removed from the damp closet and permitted to stand exposed to room atmosphere for 24 hours longer. The briquettes shall then be removed from the molds and shall be stored on edge in room atmosphere in such a way that the air can circulate freely around each briquette until ready for test.

For measuring the tensile strength of lime mortars the machine used shall be direct acting; that is, there shall be no levers introduced between the load and the specimen. The cut-off mechanism which stops the application of load shall be automatic and instantaneous. The machine shall be regulated to apply the load at the rate of 15 lb. per minute. The maximum capacity of the machine shall be not less than 50 nor more than 100 lb., and it shall be sensitive to within 1 per cent at any load.

IV. SAMPLING, INSPECTION, REJECTION, ETC.

Sampling, Retesting, Packing, Marking.

14. The sampling, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 – 22 T) of the American Society for Testing Materials.[2]

Plasticity.

15. The plasticity shall be determined by means of the apparatus shown in Fig. 1 as follows:

Three hundred grams of the sample shall be mixed with enough water to form a thick paste. This shall be covered with a damp cloth and permitted to stand for not less than 16 nor more than 24 hours.

NOTE—It is necessary that the paste be thick enough so that it can be diluted to "normal consistency" by the addition of more water, after standing. The proportion of water will vary with different limes, so that no definite amount can be recommended.

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 728.

The mold[1] shall be placed on a glass plate and filled with the paste and struck off level. The mold shall be removed immediately by raising it vertically. The final height of the paste shall be measured.

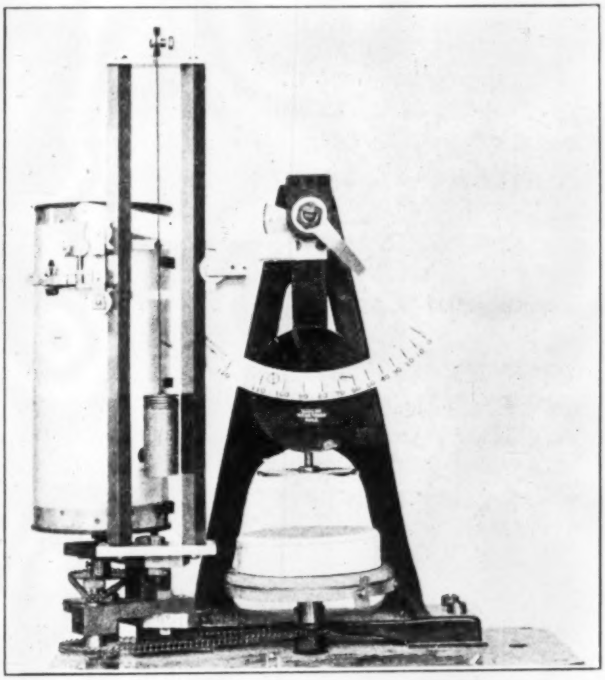

FIG. 1.—Emley Plasticimeter.

Constants of the Machine:

Absorption of porcelain base plate.—20 to 25 per cent.
Dimension of base plate.—1 in. in thickness by 4 in. in diameter.
Dimensions of disk.—$\frac{1}{32}$ in. in thickness by 3 in. in diameter.
Speed of vertical shaft.—One revolution in 6 minutes, 40 seconds.
Upward Movement of base plate.—$\frac{1}{13}$ in. per revolution.
Torque on disk when bob reading is 100.—14,400 g.c.m.

More water shall be added if necessary and the test repeated until the final height of the paste is found to be $1\frac{1}{4}$ in. $\pm \frac{1}{16}$ in. (31 mm. ± 1.5 mm.).

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[1] This mold is the same as that specified in Section 38 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials, 1921 Book of A.S.T.M. Standards.

The mold shall be placed on a porcelain base plate and filled with the paste, and struck off level. The mold shall be removed by raising it vertically without distorting the paste. The base plate and paste shall be placed in the instrument (Fig. 1) and the carriage turned up by hand until the surface of the paste comes in contact with the disk.

The carriage shall be thrown into gear and the motor started. It is essential that the motor shall be started exactly sixty seconds after the first portion of paste has been put in the mold. The time when the first portion of paste is put in the mold shall be recorded as zero time—the motor therefore is started at one minute.

The scale reading shall be taken and recorded every minute until the test is complete.

The test shall be considered complete when (*a*) the force equals 100 as shown on the scale; (*b*) any reading is less than the one before, indicating that the bob has fallen back; or (*c*) the bob has remained stationary for two consecutive readings (one minute) and the specimen has either visibly ruptured or broken loose from the base plate.

The time and the scale reading at the end of the experiment shall be noted. The time, in minutes, elapsed since zero time shall be called T and the scale reading (indicating the force) F.

The plasticity figure, P, shall be calculated from the formula:

$$P = \sqrt{F^2 + (10\ T)^2}.$$

TENTATIVE SPECIFICATIONS
FOR
QUICKLIME AND HYDRATED LIME FOR USE IN THE COOKING OF RAGS FOR THE MANUFACTURE OF PAPER.[1]

Serial Designation: C 45 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Lime in the Cooking of Rags.

1. Rags are cooked for the manufacture of paper in a digester under steam pressure with lime or with lime and soda-ash. They are then washed to eliminate as much of the non-cellulose material as possible.

I. REQUIREMENTS.

Requirements.

2. (*a*) Either quicklime or hydrated lime may be used. It shall be clean and free from gritty substances.

(*b*) The quicklime or hydrated lime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

Calcium oxide (CaO), minimum	94 per cent
Magnesium oxide (MgO), maximum	3 "
Iron and aluminum oxides (Fe_2O_3 and Al_2O_3) and insoluble matter, maximum	3 "
Carbon dioxide (CO_2), maximum:	
(*a*) If sample is taken at place of manufacture	
(1) Quicklime	3 "
(2) Hydrated lime	5 "
(*b*) If sample is taken at other than place of manufacture.	
(1) Quicklime	5 "
(2) Hydrated lime	7 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

II. METHODS OF TEST.

Chemical Analysis.

3. The chemical analysis of the lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 – 22 T) of the American Society for Testing Materials.[1]

III. SAMPLING, INSPECTION, REJECTION, ETC.

Sampling, Inspection, Rejection, etc.

4. The sampling, inspection, rejection, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 – 22 T) of the American Society for Testing Materials.[2]

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[1] See p. 715.

[2] See p. 728.

TENTATIVE SPECIFICATIONS
FOR
QUICKLIME AND HYDRATED LIME FOR USE IN THE MANUFACTURE OF SULFITE PULP.[1]

Serial Designation: C 46 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Lime in Manufacture of Sulfite Pulp.

1. Lime is used in the "Milk of Lime" or "Tank System" of sulfite pulp manufacture for making the cooking liquor. The milk of lime is held in solution or suspension in a series of tanks equipped with suitable agitators. The sulfur dioxide is forced or drawn through these tanks successively. In some cases, the tanks are built on top of each other in the form of a tower. The contents of the first tank are drawn off when the liquor has reached a certain strength (3.5 to 6 per cent total SO_2) and the contents of the second and third tanks progress to the first and second tanks respectively. The third tank is again charged with fresh milk of lime. There are other systems of absorption which provide for continuous instead of intermittent operation. The function of the lime is to furnish the base for the formation of the bisulfites of calcium and magnesium.

I. REQUIREMENTS.

Requirements.

2. (*a*) Either quicklime or hydrated lime may be used.[2] Either calcium or magnesian lime may be used, but owing to the greater solubility and reactivity of magnesian bisulfite, high magnesian lime gives the best results. The ratio of MgO to CaO shall be reasonably constant and the lime shall be moderately free from impurities. The lime shall be of such a physical nature that it will form a rapid settling sludge.

(*b*) The quicklime or hydrated lime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

[2] Quicklime is more commonly used.

Calcium oxide (CaO) and Magnesium oxide (MgO), minimum	94 per cent
Iron oxide (Fe_2O_3), aluminum oxide (Al_2O_3), Silicon oxide (SiO_2) and insoluble matter, maximum	3 "
Carbon dioxide, maximum:	
(*a*) If sample is taken at place of manufacture	5 "
(*b*) If sample is taken at other than place of manufacture	10 "

II. METHODS OF TEST.

Chemical Analysis.

3. The chemical analysis of the lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 – 22 T) of the American Society for Testing Materials.[1]

III. SAMPLING, INSPECTION, REJECTION, ETC.

Sampling, Inspection, Rejection, etc.

The sampling, inspection, rejection, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 – 22 T) of the American Society for Testing Materials.[2]

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[1] See p. 715.

[2] See p. 728.

TENTATIVE SPECIFICATIONS
FOR
HYDRATED LIME
FOR THE MANUFACTURE OF VARNISH.[1]

Serial Designation: C 47 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Lime in the Manufacture of Varnish.

1. Hydrated lime is used in the manufacture of oleo-resinous varnishes to harden and partially neutralize the rosin. About 8 lb. of hydrated lime are gradually added to 100 lb. of the melted rosin, and heated for a short period.

I. REQUIREMENTS.

Requirements.

2. (*a*) The hydrated lime shall be of such a color that no pronounced darkening of the finished varnish will result. It shall be of such a texture and of such fineness that all portions of it will rapidly come into intimate contact with the resins so as to enter into the chemical reactions with rapidity.

(*b*) The lime shall be completely hydrated[2] since a high degree of hydration is important.

(*c*) *Fineness.*—Not more than 10 per cent of the hydrated lime shall be retained on a No. 250 screen.

(*d*) *Reactivity.*—The hydrated lime shall conform to the requirements of the tung-oil heat test as indicated in Section 5.

(*e*) The hydrated lime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

Calcium oxide (CaO), minimum	94.0	per cent
Magnesium oxide (MgO), maximum	3.0	"
Iron oxide, Alumina oxide and insoluble matter, maximum	3.0	"
Iron oxide (Fe_2O_3), maximum	0.4	"
Carbon dioxide (CO_2), maximum:		
(*a*) If sample is taken at place of manufacture	3.0	"
(*b*) If sample is taken at other than place of manufracture	5.0	"

II. METHODS OF TEST.

Chemical Analysis.

3. The chemical analysis of the lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quick-

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

[2] A very high calcium lime is preferred. It is especially important that the iron content be low in order to avoid undesirable color effects.

lime and Hydrated Lime (Serial Designation: C 25 – 22 T) of the American Society for Testing Materials.[1]

Fineness. 4. One hundred grams of the sample as received shall be placed on a No. 250 sieve.[2] The material shall be washed by means of a stream of water from a faucet (Note 1). Washing shall be continued until the water coming through the sieve is clear. The residue upon the No. 250 sieve shall be dried to constant weight in an atmosphere free from CO_2 in a drying oven whose temperature is maintained between 100 and 120° C. (212 and 248° F.). The weight of this residue shall be calculated as percentage of the original sample.

NOTE 1.—A small piece of rubber tubing attached to a water faucet will be found convenient. The velocity of the stream of water may be increased by pinching the tube, but the velocity should not be sufficient to cause any danger of splashing the sample over the sides of the sieve.

Tung Oil Heat Test. 5. Fifty grams of raw tung oil shall be placed in a 100-cc. beaker and 1 g. of hydrated lime stirred in. A cloudy mass will result. Heat shall then be applied. High-quality hydrated lime will usually start to react at approximately 80° C. (176° F.), small bubbles rising to the surface. As heating is continued, large flakes of lime tungate will form and rise to the surface to form a thick white scum and the oil below will gradually become fairly clear. These changes will usually be completed when a temperature of 120° C. (248° F.) is reached. The heating shall be continued until the mass reaches a temperature of 140° C. (284° F.). It shall then be allowed to cool and the formation of the thick scum on the surface noted which will, when freed of air, gradually drop to the bottom of the beaker. This scum consists of tung oil soaps of lime which are quite insoluble in the oil. Addition of rosin will readily effect solution of these soaps.

A poor grade of lime will fail to react, the absence of bubbles or flakes of lime tungate being noticeable. The oil will remain quiescent and cloudy. Only small amounts of soaps will form on the surface.

III. SAMPLING, INSPECTION, REJECTION, ETC.

Sampling, Inspection, Rejection, etc. 6. The sampling, inspection, rejection, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 – 22 T) of the American Society for Testing Materials.[3]

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[1] See p. 715.

[2] See specifications for U. S. Standard Sieve series in a publication now being prepared to supersede *Circular No. 39* of the U. S. Bureau of Standards.

[3] See p. 728.

TENTATIVE SPECIFICATIONS
FOR
QUICKLIME AND HYDRATED LIME FOR USE IN THE TEXTILE INDUSTRY.[1]

Serial Designation: C 48 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Lime in Textile Industry.

1. Lime is used in the textile industry for the following operations:
   - (*a*) Liming the kiers.
   - (*b*) Boiling out or scouring.
   - (*c*) Bleaching.
   - (*d*) Mercerizing.
   - (*e*) Water Softening.

These specifications apply only to the first three operations[2] in connection with the treatment of the vegetable fibers: cotton, linen and jute.

2. (*a*) Kier liming consists of applying a coating of whitewash to the inside of the kier and heating with steam. These two operations are repeated until a coat of the desired thickness is obtained. The lime serves to prevent the fibers from being stained by the iron kier.

(*b*) The boiling-out process consists of soaking the fibers in a milk of lime, passing them through rollers into a kier, covering the fibers with water and boiling with steam either at atmospheric or higher pressures. The fibers then pass through a series of washings and treatments with acid and soda-ash. The function of the lime is to saponify, hydrolyze and neutralize whereby it makes possible, in following operations, the removal of fatty and greasy matters and pectin bodies. The fibers then consist of practically pure cellulose, the impurities being coloring matter not decomposed by alkalis.

(*c*) Lime is used in the bleaching operation for making the "chemic" solution or hypochlorite bath. This bath may be made from bleaching powder or from lime and liquid chlorine. These specifications are limited to the process involving the use of lime and liquid chlorine. The operation consists of making a milk of lime and introducing chlorine under carefully controlled conditions until the mixture is nearly neutral. The sludge is allowed to settle and the clear hypochlorite solution is drawn off. After bleaching, the fibers are soured and washed, and then passed on to the soda-ash boil. Lime serves as a carrier of chlorine under conditions whereby the liberation of nascent oxygen and the resulting oxidation can be controlled in accordance with the special requirements of textile fibers. Bleaching decolorizes the fibers by oxidation of the coloring matter. It probably performs several other functions also about which there is not general agreement.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

[2] Work is in progress on separate specifications for causticization (which is involved in mercerization) and water purification.

I. REQUIREMENTS.

Requirements.

3. (*a*) Either quicklime or hydrated lime of fairly high calcium content may be used.[1] The lime shall be fresh and substantially free from ash, dirt and core, and shall be very reactive chemically.

(*b*) The quicklime or hydrated lime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

Calcium oxide (CaO), minimum	94.0	per cent
Magnesium oxide (MgO), maximum	3.0	"
Iron and Aluminum oxides (Fe_2O_3 and Al_2O_3), maximum	2.0	"
Silica (SiO_2) and insoluble matter, maximum	2.5	"
Carbon dioxide (Co_2), maximum:		
(*a*) If sample is taken at place of manufacture		
(1) Quicklime	3.0	"
(2) Hydrated lime	5.0	"
(*b*) If sample is taken at other than place of manufacture		
(1) Quicklime	5.0	"
(2) Hydrated lime	7.0	"

II. METHODS OF TEST.

Chemical Analysis.

4. The chemical analysis of the lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 – 22 T) of the American Society for Testing Materials.[2]

III. SAMPLING, INSPECTION, REJECTION, ETC.

Sampling, Inspection, Rejection, etc.

5. The sampling, inspection, rejection, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 – 22 T) of the American Society for Testing Materials.[3]

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[1] There is a tendency to prefer quicklime for the boiling out and kier liming process, and hydrated lime for the mordanting process. Quicklime or hydrated lime which contains iron in a readily soluble form should be avoided as should also hydrated lime which contains a considerable amount of unhydrated magnesia.

[2] See p. 715

[3] See p. 728.

TENTATIVE SPECIFICATIONS
FOR
QUICKLIME AND HYDRATED LIME FOR THE MANUFACTURE OF SILICA BRICK.[1]

Serial Designation: C 49 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Lime in Manufacture of Silica Brick.

1. In the manufacture of silica brick, silica, preferably quartzite, in ground in a wet-pan until the particles are less than $\frac{1}{4}$ in. in size. Milk of lime is then added in quantities varying from 1.5 to 4 per cent CaO and the shapes are molded and dried. When bone dry they are burned in down-draft kilns until most of the quartzite has been converted into tridymite and christobalite.

I. REQUIREMENTS.

Requirements.

2. Either quicklime or hydrated lime may be used. It shall be substantially free from ash, dirt and core. Fineness of hydrate and rapidity of slaking of quicklime are desirable qualities.

(*b*) The quicklime or hydrated lime shall conform to the following requirements as to chemical composition, calculated to the non-volatile basis:

Calcium oxide (CaO), minimum	92.0	per cent
Magnesium oxide (MgO), maximum	3.0	"
Combined Iron and Aluminum oxides (Fe_2O_3 and Al_2O_3), maximum	1.5	"
Silica (SiO_2) and insoluble matter, maximum	3.0	"
Carbon dioxide (CO_2), maximum:		
(*a*) If sample is taken at place of manufacture	5.0	"
(*b*) If sample is taken at other than place of manufacture	10.0	"

II. METHODS OF TEST.

Chemical Analysis.

3. The chemical analysis of the lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 - 22 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

[2] See p. 715.

III. SAMPLING, INSPECTION, REJECTION, ETC.

Sampling, Inspection, Rejection, etc.

4. The sampling, inspection, rejection, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 - 22 T) of the American Society for Testing Materials.[1]

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[1] See p. 728.

TENTATIVE SPECIFICATIONS

FOR

GYPSUM.[1]

Serial Designation: C 22 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1919; REVISED, 1920, 1921, 1922.

I. MATERIALS AND STANDARDS.

Testing.

1. The chemical and physical properties of gypsum shall be determined in accordance with the Tentative Methods of Testing Gypsum and Gypsum Products (Serial Designation: C 26–21 T) of the American Society for Testing Materials.[2]

Definition.

2. (*a*) Pure gypsum is calcium sulfate combined in crystallin form with two molecules of water.

(*b*) Its chemical formula is $CaSO_4 \cdot 2H_2O$.

(*c*) No material may be considered gypsum within the meaning of these specifications which contains less than 64.5 per cent by weight of $CaSO_4 \cdot 2H_2O$.

Forms and Sizes.

3. Gypsum may be marketed in any of the following forms and sizes:

(*a*) *Run-of-Mine.*—The form in which it comes from the mine or quarry.

(*b*) *Crushed.*—Run-of-mine gypsum further reduced so that all of it will pass through a 2-in. (50.8 mm.) ring, and not less than 10 per cent shall be retained on a No. 3 sieve.

(*c*) *Crushed Gypsum, Sized.*—Shall all pass a No. 3 sieve, and not less than 10 per cent shall be retained on a No. 8 sieve.

(*d*) *Ground.*—Crushed gypsum further reduced to sizes suitable for specific uses. Ground gypsum may be marketed in any of the following sizes:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Washington St., Chicago, Ill.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 590 (1921).

No. 1.—Material of this size shall all pass a 14-mesh sieve, and not less than 85 per cent of it shall pass a 100-mesh sieve.

No. 2.—Material of this size shall all pass a 14-mesh sieve, and not less than 60 nor more than 85 per cent of it shall pass a 100-mesh sieve.

No. 3.—Material of this size shall all pass an 8-mesh sieve, and not less than 40 nor more than 60 per cent of it shall pass a 100-mesh sieve.

Chemical Properties.

4. The chemical composition, within the limits prescribed by Section 2, shall be a matter of contract.

II. SAMPLING.

Sampling from Bulk.

5. When gypsum is shipped in bulk, samples of about 5 lb. (2.25 kg.) each shall be taken at regular intervals during the complete loading or unloading of the carrier, in such a way as to accumulate at least 200 lb. (90 kg.) of material, and to represent correctly the percentages of both the coarse particles and the fines in the shipment. This shall be broken so that it will all pass a 1-in. (25-mm.) ring, thoroughly mixed, and reduced by quartering to provide not less than a 1-lb. (0.5-kg.) sample for the laboratory.

Sampling from Packages.

6. When gypsum is shipped in packages, at least 3 per cent of the packages shall be sampled. Samples shall be taken from both the surface and the center of the packages. These samples shall then be broken, mixed, and quartered as directed above.

Laboratory Samples.

7. All laboratory samples shall be placed immediately in an air-tight container and shipped to the laboratory for test.

III. PACKING AND MARKING.

Packing and Marking.

8. (*a*) Gypsum may be shipped either in packages or in bulk.

(*b*) When shipped in packages for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Form and size of material;
Chemical analysis of the material, giving the minimum percentages of CaO and SO_3;
Net weight of package.

(*c*) When shipped in bulk, a card containing the required information shall be conspicuously placed in the carrier.

IV. INSPECTION AND REJECTION.

Inspection. 9. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection. 10. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing. 11. Claims for rehearing shall be valid only if made within 20 working days from receipt of notice of specific cause for rejection.

TENTATIVE SPECIFICATIONS
FOR
GYPSUM WALL BOARD.[1]

Serial Designation: C 36 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1921; Revised, 1922.

Definition. 1. Gypsum wall boards are incombustible boards which, without the addition of plaster, furnish to interior walls, ceilings or partitions a surface which may receive decoration.

Composition. 2. Gypsum wall boards consist of sheets or slabs composed of one layer of gypsum, with or without fiber, reinforced on the surfaces with a covering made from fibrous material.

Thickness. 3. Gypsum boards shall be $\frac{3}{8}$ in. (9.5 mm.) thick with permissible local variations of $\pm\frac{1}{32}$ in. (0.8 mm.).

Note.—Gypsum wall boards are manufactured in thicknesses from $\frac{1}{4}$ in. (6.3 mm.)to $\frac{1}{2}$ in. (12.7 mm.) with permissible local variations of $\pm\frac{1}{32}$ in. (0.8 mm.) from the nominal thickness.

Dimensions. 4. (*a*) Gypsum wall boards that are to be laid with the joints butted shall have widths of 32 in. (810 mm.), 36 in. (910 mm.), or 48 in. (1220 mm.), except that a variation of $\frac{3}{32}$ in. (2 mm.) under the specified widths is permissible.

(*b*) Gypsum wall boards that are to be laid with the joints filled shall have widths $\frac{1}{4}$ in. (6.3 mm.) less than those specified in Paragraph (*a*) except that the same variation is permissible.

(*c*) The lengths shall be 4 ft. (1.22 meter), 5 ft. (1.52 meter), 6 ft. (1.83 meter), 7 ft. (2.13 meter), 8 ft. (2.44 meter), or 10 ft. (3.04 meter), except that a variation of $\pm\frac{3}{8}$ in. (9.5 mm.) from these lengths is permissible.

Weight. 5. The weight of gypsum wall board shall be not less than 1500 lb. (680 kg.) nor more than 2000 lb. (907 kg.) per 1000 sq. ft.

Strength. 6. (*a*) Strength test specimens shall be 12 in. (300 mm.) wide and approximately 18 in. (460 mm.) long, and when tested shall be supported on parallel knife-edge bearings spaced 16 in. (410 mm.) apart, and shall be loaded through a similar bearing midway between the supports.

(*b*) When tested as described, specimens taken from the gypsum wall boards shall carry a load of not less than 60 lb. (27.22 kg.) when the knife edges are across the fiber of the surfacing, and not less than

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Washington St., Chicago, Ill.

32 lb. (14.51 kg.) when the knife edges are parallel to the fiber of the surfacing.

(*c*) With loads equal to or less than those specified in Paragraph (*b*) there shall be no breaking of the bond between the surfacing and the core.

Finish.

7. That surface of the gypsum wall board designed to be exposed on erection shall be true and free from imperfections that would render the wall boards unfit for use with or without decorations. The edges and ends shall be straight and solid. Boards that are to be butted shall have corners square and opposite edges parallel to each other. With boards that are to have the joints filled, a negative variation of $\frac{1}{8}$ in. (3 mm.) from parallelism of opposite edges is permissible.

Sampling.

8. At least one per cent of the number of gypsum wall boards in a shipment, but not less than ten boards, shall be so selected as to be representative of the shipment. Twenty-five per cent of such selected boards, but not less than ten individual boards, shall constitute a sample for test purposes. When a shipment consists of more than one car or carrier load, a sample shall be selected from each car or carrier.

Packing and Marking.

9. Shipments of gypsum wall board shall conform to the following:

(*a*) They shall be shipped so as to be kept dry and free from moisture.

(*b*) When shipped for resale the following information shall be shown upon each board:

Name of manufacturer;
Brand;
Nominal thickness.

Inspection.

10. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection.

11. Any rejection shall be based upon failure to conform to the requirements of these specifications and shall be reported within ten working days from the receipt of the shipment by the consignee. The notice of rejection shall contain a specific statement of the respects in which the boards have failed to meet the requirements of these specifications.

Rehearing.

12. Claims for rehearing shall be valid only if made within twenty working days from receipt of notice of specific cause for rejection.

TENTATIVE SPECIFICATIONS
FOR
GYPSUM PLASTER BOARD.[1]

Serial Designation: C 37 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Definition. 1. Gypsum plaster boards are an incombustible lath or backing for the application of gypsum plaster upon the walls, ceilings and partitions in the interior of buildings.

Composition. 2. Gypsum plaster boards consist either of sheets or slabs composed of one or more layers of gypsum, with or without fiber, reinforced on the surfaces with a covering made from fibrous material; or of sheets or slabs composed of an intimate mixture of gypsum and fibrous binding material.

Thickness. 3. Gypsum plaster boards shall be $\frac{1}{4}$ in. (6.3 mm.), $\frac{5}{16}$ in. (8.0 mm.), $\frac{3}{8}$ in. (9.5 mm.), or $\frac{1}{2}$ in. (12.7 mm.) thick, except that average thicknesses varying not more than $\frac{1}{16}$ in. (1.6 mm.) from the nominal thickness, and local variations of $\frac{1}{16}$ in. (1.6 mm.) in the thickness of the individual boards are permissible.

Dimensions. 4. The nominal width of gypsum plaster boards shall be 32 in. (810 mm.), and the nominal length 24 in. (610 mm.), 36 in. (910 mm.) or 48 in. (1220 mm.). A variation of $\frac{1}{4}$ in. (6.3 mm.) under the specified width, and of $\frac{3}{8}$ in. (9.5 mm.) under or over the specified length is permissible.

Weight. 5. The weight of gypsum plaster board per 1000 sq. ft. shall conform to the following:

THICKNESS.		WEIGHT, MINIMUM.		WEIGHT, MAXIMUM.	
IN.	MM.	LB.	KG.	LB.	KG.
$\frac{1}{4}$	6.3	1200	544	1500	680
$\frac{5}{16}$	8	1250	567	1650	750
$\frac{3}{8}$	9.5	1500	680	2000	907
$\frac{1}{2}$	12.7	2000	907	3000	1361

Strength. 6. (*a*) Strength test specimens shall be 12 in. (300 mm.) wide and approximately 18 in. (460 mm.) long, and when tested shall be supported on parallel knife-edge bearings spaced 16 in. (410 mm.) apart, and shall be loaded through a similar bearing midway between the supports. Test loads shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ± 10 per cent in the rate.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Washington St., Chicago, Ill.

(*b*) When tested as described, specimens taken from the gypsum plaster boards shall carry not less than the following loads:

BOARD THICKNESS, IN.	LOAD, LB.	
	KNIFE EDGES ACROSS FIBER OF SURFACING.	KNIFE EDGES PARALLEL TO FIBER OF SURFACING.
⅜	40	20
5/16	35	17
¼	30	14

(*c*) With loads equal to or less than those specified in Paragraph (*b*) there shall be no breaking of the bond between the surfacing and the core.

(*d*) Gypsum plaster boards that are ½ in. (12.7 mm.) thick, or those that are not reinforced on the surfaces with a covering made from fibrous material, when tested as described in Paragraph (*a*), shall carry an ultimate center load of not less than 20 lb. (9.07 kg.).

Finish.

7. The surfaces shall be such that they will readily receive and retain gypsum plaster. The edges and ends shall be reasonably straight and solid. The corners shall be square with a permissible variation of ¼ in. (6 mm.) in the full width of the plaster boards. Gypsum plaster boards shall be free from cracks and imperfections that will render them unfit for use.

NOTE.—Gypsum plaster boards that have their corners blurred or broken shall be considered acceptable, provided that the broken portion is not more than 1½ in. (38 mm.) in length.

Sampling.

8. At least one per cent of the number of gypsum plaster boards in a shipment, but not less than ten boards, shall be so selected as to be representative of the shipment. Twenty-five per cent of such selected boards, but not less than ten individual boards, shall constitute a sample for test purposes. When a shipment consists of more than one car or carrier load, a sample shall be selected from each car or carrier.

Packing and Marking.

9. Shipments of gypsum plaster board shall conform to the following:

(*a*) They shall be shipped so as to be kept dry and free from moisture.

(*b*) When shipped for resale the following information shall be shown upon each board:

Name of manufacturer;
Brand;
Nominal thickness.

Inspection. 10. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection. 11. Any rejection shall be based upon failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee. The notice of rejection shall contain a specific statement of the respects in which the boards have failed to meet the requirements of these specifications.

Rehearing. 12. Claims for rehearing shall be valid only if made within twenty working days from receipt of notice of specific cause for rejection.

TENTATIVE METHODS OF CHEMICAL ANALYSIS
OF
LIMESTONE, QUICKLIME AND HYDRATED LIME.[1]

Serial Designation: C 25 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1919; REVISED, 1921, 1922.

TREATMENT OF SAMPLE

Treatment of Sample.

The sample, taken and prepared in accordance with the requirements of the particular specifications of the Society applicable to the material shall be treated as follows:

Weigh out 0.5 g. of the substance and, if a limestone or hydrated lime, ignite in a covered platinum crucible in an electric muffle (Note 1) for 15 minutes, or longer if the heat is not powerful enough to effect complete decomposition within that time. Transfer to an evaporating dish, preferably of platinum (Note 2) for the sake of celerity in evaporation, mix to a thin slurry with distilled water, add 5 to 10 cc. of HCl (sp. gr. 1.20) and digest with aid of gentle heat and agitation until solution is complete. Solution may be aided and the time shortened by light pressure with the flattened end of a glass rod upon resistant lumps. Then evaporate the solution to dryness, so far as this may be possible on the water bath.

DETERMINATION OF SILICA.

Silica.

When dry or nearly so, place the dish and its contents in an air bath or (covered) on a platinum triangle resting on a hot plate and, if it is a high calcium limestone that is under treatment, heat for one hour at 200° C.; if a high magnesian stone is under treatment the temperature should not exceed 120° C. Drench the cooled mass with HCl (sp. gr. 1.20) and allow to stand for a few minutes. Add an equal volume of water, cover the dish and place on the water bath for

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[1] *Bulletin 700*, U. S. Geological Survey, should be used as a reference book in connection with these methods, especially when very exact and detailed analyses are desired. Blank determinations should be made on all reagents, and corrections applied when called for.

Criticisms of these Tentative Methods are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

10 minutes (Note 3). Separate the silica by filtration on a filter of suitable size. Wash thoroughly with dilute HCl and then wash twice with cold water.

Evaporate the filtrate to dryness. Extract the residue with HCl as before but allowing only a few minutes time. Filter this solution through a second and smaller paper.

Transfer, wet, the papers containing the separated residue to a weighed platinum crucible. Char carefully without allowing the paper to inflame and ignite to constant weight in an electric muffle and weigh (Note 1). Correct the weighed silica for foreign matter by evaporating with 5 cc. of HF and one or two drops of H_2SO_4.[1] Heat the residue for 2 or 3 minutes in an electric muffle and again weigh. The difference between this weight and that previously obtained gives the weight of the silica (Note 4).

DETERMINATION OF TOTAL IRON AND ALUMINUM.

Iron and Alumina.

Fuse the residue from the silica determination using a little Na_2CO_3 (Note 5). Dissolve the cooled melt in HCl and add the solution to the filtrate from the second evaporation for silica. Add a few drops of bromine water or HNO_3 and boil the solution until all trace of bromine or chlorine is gone. Then add HCl, if not already present, sufficient to insure a total volume of 10 to 15 cc. of HCl (sp. gr. 1.20).[2] Add a few drops of methyl red solution and after diluting to 200 to 250 cc. heat the liquid to boiling. Neutralize by means of NH_4OH (dilute towards the end) until the color of the liquid changes to a distinct yellow. Boil for one or two minutes, allow to settle, filter and wash the precipitate at once two or three times with hot NH_4Cl (2-per-cent) solution and suck dry.[3]

Set the filtrate aside. Dissolve any precipitate from the paper in hot, dilute HCl, the solution passing into the beaker in which the precipitation was made and wash the paper thoroughly with hot water. Boil the solution to expel any trace of chlorine and again precipitate the hydroxides with NH_4OH as described above. Ignite the precipitate, moist (Note 1), in a weighed platinum crucible, cool and weigh as Al_2O_3 and Fe_2O_3 (Note 6).

DETERMINATION OF TOTAL IRON.

Total Iron.

Fuse the combined iron and aluminum oxides (Note 7) in a platinum crucible at a very low temperature with 3 to 4 g. of $K_2S_2O_7$ or better $Na_2S_2O_7$ (Note 8). Take up the melt with so much dilute H_2SO_4 that there shall be not less than 5 g. absolute acid and enough water to effect solution on heating. Evaporate the solution and eventually heat until acid fumes come off copiously. After cooling and redissolving in water, filter out the small amount of silica, wash, ignite, weigh and correct by HF and H_2SO_4 (Note 9). Add the weight so corrected to the weight of silica previously found and deduct from the gross weight of the oxides of iron and aluminum.

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[1] See *Bulletin 700*, U. S. Geological Survey, p. 103.

[2] See *Bulletin 700*, U. S. Geological Survey, p. 258.

[3] See *Bulletin 700*, U. S. Geological Survey, p. 107.

Reduce the filtrate by zinc (Note 10). Titrate with $KMnO_4$ using a N/20 solution.

DETERMINATION OF ALUMINUM.

Aluminum.

Subtract the calculated weight of Fe_2O_3 obtained by the method described above from the weight of $Fe_2O_3 + Al_2O_3$. Report the remainder as Al_2O_3. In case phosphorus is determined, calculate it to P_2O_5 and deduct also.

DETERMINATION OF TOTAL IRON.

ALTERNATIVE METHOD (Note 7).

Total Iron, Alternative.

Dissolve 2 to 5 g. (depending upon the amount of iron present) of the properly prepared sample in HCl and evaporate rapidly to dryness. Treat the residue with water and HCl, filter off the silica and wash several times with hot water. Precipitate the iron in a boiling solution with fixed alkali, allow to settle, filter and wash free of chlorides, using hot water. Dissolve in dilute H_2SO_4.

Ignite the insoluble matter from the evaporated hydrochloric acid solution in a platinum crucible. Treat with H_2SO_4 and HF and heat until fumes of H_2SO_4 appear. Bring the residue into solution with the addition of a few drops more of H_2SO_4 and combine the solution with that of the bulk of the iron. Reduce this solution by zinc and titrate the iron with $KMnO_4$ in the usual manner.

DETERMINATION OF CALCIUM.

(Note 11.)

(*a*) *Gravimetric Method.*

Calcium, Gravimetric.

Add a few drops of NH_4OH to the combined filtrate from the R_2O_3 precipitate, and bring the solution to boiling. To the boiling solution add 35 cc. of a saturated solution of $(NH_4)_2C_2O_4$, and continue the boiling until the precipitated CaC_2O_4 assumes a granular form; then allow it to stand 20 minutes, or until the precipitate has settled and the supernatent liquid is clear, filter and wash thoroughly with boiling water (Note 12). Place the wet filter and precipitate in a platinum crucible, and burn off the paper over the small flame of a Bunsen burner, or in a muffle. Ignite the residue, dissolve in hot dilute HCl, and make up the volume of the solution to 100 cc. with water. Add NH_4OH in slight excess and boil the liquid. If a small amount of $Al_2(OH)_6$ separates, filter it out, wash with NH_4Cl (2-per-cent solution), ignite, weigh and add this weight to that found in the first determination. Then reprecipitate the lime by $(NH_4)_2C_2O_4$ allow to stand until settled, filter, wash thoroughly with boiling water (Note 12) and weigh as calcium oxide after ignition to constant weight in a covered platinum crucible.

(*b*) *Volumetric Method.* (Note 13.)

Calcium, Volumetric. Make the filtrate from the iron and alumina precipitate alkaline with NH_4OH, boil, and add 35 cc. of a boiling saturated solution of $(NH_4)_2C_2O_4$. Stir vigorously and allow to stand until the precipitate has settled, filter on an 11-cm. paper, and wash ten times with hot water (Note 14). Transfer the paper and precipitate to the beaker in which the precipitation was made, spreading the paper out against the upper portion of the beaker. Wash the precipitate from the paper with a jet of hot water, fold the paper and leave it adhering to the upper portion of the beaker. Add to the contents of the beaker 50 cc. of dilute H_2SO_4 (1:10), dilute to a volume of 250 cc. with hot water and heat to a temperature of 80 to 90° C. Titrate with the standard $KMnO_4$ solution[1] until the pink end point is obtained. Now drop the folded filter paper (which has been adhering to the side of the beaker) into the liquid; the pink color of the latter will be discharged. Finish the titration by adding $KMnO_4$, a drop at a time, until the pink end point is again obtained. A Gooch crucible may be used instead of filter paper. From the total quantity of standard $KMnO_4$ solution used, calculate the percentage of calcium oxide.

DETERMINATION OF STRONTIUM.

Strontium. Transfer the weighed oxides obtained in the gravimetric determination of calcium to a small flask of 20-cc. capacity and dissolve in HNO_3. Evaporate to dryness and heat at 150 to 160° C. Treat the thoroughly dried nitrates with as little (rarely over 2 cc.) of a mixture of equal parts of absolute alcohol and ether as may be needed to dissolve the calcium salt, solution being hastened by occasional gentle agitation. After standing over night in the corked flask collect the insoluble matter on the smallest possible filter and wash with more of the above mixture of alcohol and ether. After drying, pass a few cubic centimeters of hot water through the filter, on which may remain a few tenths of a milligram of residue, which does not usually contain any lime or other alkaline earth and whose weight is therefore to be deducted from that of the lime, unless it can be shown that it is derived from the glass of the little flask in which the nitrates of calcium and strontium were evaporated. To the solution of strontium nitrate in a small beaker add a few drops of H_2SO_4 and then its volume of alcohol, whereby the strontium is precipitated as sulfate. After twelve hours, filter on a small filter paper and wash the residue with 50-per-cent alcohol. Ignite at a low temperature, moisten with dilute H_2SO_4, evaporate, again ignite and weigh as strontium sulfate. Test the sulfate spectroscopically as to freedom from calcium and barium.

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[1] See directions for preparing this solution.

Calculate the weight of strontium oxide and deduct from the weight of calcium oxide obtained as above.

DETERMINATION OF MAGNESIUM.

Magnesium.

Acidify the combined filtrates from the calcium precipitates with HCl and concentrate on the water bath to about 150 cc., and heat to boiling. To the boiling solution add 10 cc. of a saturated solution of $Na(NH_4)HPO_4$ and continue the boiling for several minutes. Then cool to room temperature, and add NH_4OH drop by drop with constant stirring until the crystallin ammonium-magnesium orthophosphate begins to form and then in moderate excess, the stirring being continued for several minutes. Allow the liquid to stand in a cool atmosphere for from 12 to 48 hours (Note 15) and filter.

Dissolve the precipitate in hot dilute HCl, make up the solution with water to about 100 cc., add 1 cc. of the saturated solution of $Na(NH_4)HPO_4$ and NH_4OH drop by drop with constant stirring until the precipitate is again formed as above described and the ammonia is present in moderate excess. Then allow it to stand in a cool atmosphere for from 12 to 48 hours (Note 15), filter on paper or a Gooch crucible, wash with dilute NH_4OH containing NH_4NO_3 (Note 16), ignite (Note 1), cool, and weigh as $Mg_2P_2O_7$ (Note 17).

DETERMINATION OF TOTAL VOLATILE MATTER.

(LOSS ON IGNITION.)

Volatile Matter.

Place 1 g. of the properly prepared sample (Note 18) in a weighed platinum crucible, cover with the lid and heat gently for 5 minutes (Note 1), gradually increasing the temperature to the maximum of the muffle, and maintain at this temperature until constant weight is obtained (usually about 15 minutes).

DETERMINATION OF MECHANICAL MOISTURE.

(LIMESTONE ONLY.) (Note 19.)

Mechanical Moisture.

Weigh 1 g. of the properly prepared sample in a tared, wide, low-form, flat-bottomed weighing bottle. Heat uncovered in a ventilated drying oven at 120° C. for two hours. Quickly stopper and cool in a desiccator. Lift the stopper momentarily just before weighing and weigh. The use of a similar weighing bottle as a counterpoise carried through all of the operations is a desirable procedure. The loss in weight represents "Mechanical Moisture" or "Hydroscopic Water" at 120° C.

DETERMINATION OF CARBON DIOXIDE.

Carbon Dioxide. Carbon dioxide is to be determined upon the properly prepared sample according to the method given in U. S. Geological Survey Bulletin No. 700, p. 217. An illustration showing the arrangement of the component parts of the necessary apparatus is shown on p. 218 of that Bulletin.

With limestone, use a 0.5-g. sample; with burned lime, hydrated lime, etc., use a 5-g. sample.

Boil the weighed sample with dilute HCl in a small Erlenmeyer flask attached to an upwardly inclined condenser, whence, after passing through a drying system—calcium chloride, anhydrous copper sulfate to retain hydrogen sulfide from decomposable sulfides and any HCl that may pass over, then calcium chloride again—the carbon dioxide is caught by absorption tubes filled with soda-lime followed by calcium chloride. Of course, arrangement is made for a current of air free from CO_2 with which to sweep out the apparatus before and after the experiment, and for a slow current during its continuance.

The results are very accurate and the determination can be quickly carried out.

The manipulations are as follows: Pour hot water upon the powder in the flask fitted with a separatory funnel and delivery tube; attach this to the condenser, and force a current of air free from CO_2 through the whole system, except the weighed absorption tubes, until the original air has been displaced, the observation bulbs (containing H_2SO_4 to show the rate of gas flow) being attached directly to the drying system. Then close the stop-cock in the separatory funnel, half fill the latter with HCl (1:1), replace the rubber stopper of the funnel, insert the absorption tubes between the drying system and the observation bulbs, and allow the acid to flow into the flask, slowly if there is much carbon dioxide, rapidly if there is but little. When effervescence diminishes in the former case, at once in the latter, light the burner under the flask and start the flow of water through the condenser. Keep the flame low, so as to secure steady but quiet ebullition, and do not interrupt the air current although it should be reduced to a slow rate. With much carbon dioxide the rate of absorption is very readily noted by holding the hand to the soda-lime tubes, which become hot or warm when absorption is taking place. Sufficient time having elapsed (Note 20), extinguish the flame, and increase the air current. When cool, disconnect the soda-lime tubes from the apparatus and allow to stand in the balance case until two weights taken 30 minutes apart agree within 0.5 mg.

The soda lime for use in this determination must be porous, not hard and unabsorptive like that sometimes used for the combustion of nitrogenous organic substances.

DETERMINATION OF SULFURIC ANHYDRIDE.

Sulfuric Anhydride.

Place 2 g. of the properly prepared sample in a small, dry beaker and stir it up with 10 cc. of cold water until all lumps are broken up and the lighter particles are in suspension. Add 15 cc. of dilute HCl (1 : 1) and heat until solution is complete. Filter through a small paper and wash the residue thoroughly with hot water. Dilute the filtrate to 250 cc., heat to boiling, and add 10 cc. of a boiling 10-per-cent solution of barium chloride drop by drop with constant stirring. Stir well and allow to stand over night. Filter, wash with boiling water, ignite and weigh as $BaSO_4$.

DETERMINATION OF TOTAL SULFUR.

Total Sulfur.

Digest 2 g. of the properly prepared sample on the hot plate with 25 to 30 cc. of bromine water. Then add 15 cc. of dilute HCl (1:1) and boil until solution is complete and all bromine has been expelled. Then proceed as outlined above under "Determination of Sulfuric Anhydride."

DETERMINATION OF PHOSPHORUS.

Phosphorus.

Dissolve 10 g. of the sample in 80 cc. of dilute HNO_3 (1:1), filter, and wash the residue with hot water. Ignite, and fuse the residue with a little Na_2CO_3, cool the melt and add its nitric acid solution to the main filtrate. (Note 21.)

In case the rock is rather argillaceous, mix the powder with half its weight of Na_2CO_3 and blast strongly. Dissolve the cooled melt in HNO_3 and evaporate to dryness. Take up the dry residue with dilute HNO_3 (1 : 2), filter and wash the residue with hot water. Ignite the residue in platinum, and evaporate with HF and HNO_3. Finally, evaporate twice with HNO_3 alone to expel all fluorine, dissolve the residue in HNO_3 and add the solution to the main filtrate. (Note 21.)

Oxidize the nitric acid solution by boiling with 10 cc. of 1.5-per-cent $KMnO_4$ solution until manganese dioxide is precipitated. Dissolve the oxide by addition of H_2SO_3 or a sulfite free from phosphorus and boil to expel the oxides of nitrogen and sulfur. Neutralize the HNO_3 with NH_4OH and then add 1 cc. of HNO_3 (sp. gr. 1.42) for every 100 cc. of solution. Bring the solution to a temperature of 40° C., add ammonium molybdate solution[1] and shake for 10 minutes. Allow to stand at a temperature of not over 40° C. for 1 to 12 hours. Filter and wash 10 times with a 1-per-cent KNO_3 solution. Return the precipitate to the precipitating vessel, add a measured excess of N/10 NaOH and 25 cc. of water free from CO_2 and shake or stir until the precipitate is dissolved. Dilute to 100 to 200 cc. with water free from CO_2, add 3 drops of 0.2-per-cent phenolphthalein solution, and discharge the pink color with standard acid. Finish the titration by adding standard alkali until the reappearance of the pink color. The alkali solution should be free from carbonate and be standardized against the Bureau of Standards' standard benzoic acid.[2] The ratio of phosphorus to NaOH should be considered as 1 : 23 in calculating results. (Note 22.)

DETERMINATION OF MANGANESE.

Manganese.

Dissolve 10 g. of the sample in 100 cc. of dilute HNO_3 (1 : 1), filter and wash the residue with hot water. Ignite the residue in platinum, fuse with a little Na_2CO_3 and add the nitric acid solution of the melt to the main filtrate.

Dilute the solution to 150 cc. and add 0.5 g. of sodium bismuthate (Note 23). Heat for a few minutes, or until the pink color has disappeared and dioxide has precipitated. If manganese dioxide does not precipitate add more bismuthate. Clear the solution by adding a few drops of a saturated solution of sodium bisulfite or other suitable reducing agent free from chlorides, and boil to expel all oxides of nitrogen and sulphur. Cool to 15° C., add an excess of sodium bismuthate, agitate and let stand for a few minutes. Add 50 cc. of 3-per-cent HNO_3 and filter through asbestos. Wash with 3-per-cent HNO_3 until the washings run through colorless. Add a measured excess of a standard $FeSO_4$ solution and titrate back with a standard $KMnO_4$ solution of which the strength has been determined by means of the Bureau of Standards sodium oxalate. (Note 24.)

DETERMINATION OF FERROUS IRON SOLUBLE IN SULFURIC ACID.

Ferrous Iron.

In limestones, the presence of carbonaceous matter renders the exact or even approximate determination of ferrous iron often impossible. Nevertheless, even in its presence acceptable results are sometimes obtainable if there is not much of such matter and if it does not give with acid a colored solution. Occasionally limestones show films of manganese peroxide, which likewise interferes with the determination.

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[1] See Blair, "The Chemical Analysis of Iron," 8th Edition, p. 92.

[2] See *Journal*, Am. Chem. Soc., Vol. 34, p. 1027 (1912), and Vol. 35, p. 1309 (1913).

(a) *In Absence of Carbonaceous Matter.*

The powder, one to several grams, is introduced into a stout flask of about 200 to 250-cc. capacity and boiled with a little water till all air is expelled. While still boiling, dilute H_2SO_4 is added, a little at a time, till effervescence ceases, and then a further amount. Calcium sulfate precipitates, but the iron will remain in solution. The flame is then removed and a stopper tightly inserted, through which passes a small stop-cock funnel. When cool, or nearly so, cold water is poured into the funnel, the cock cautiously opened, and the water drawn into the flask, more water being poured into the funnel as fast as it empties, till the solution amounts to 100 to 150 cc. Such precaution to exclude air is hardly necessary in most cases, however, for in presence of H_2SO_4 the oxidation of ferrous iron is exceedingly slow. It is ordinarily quite sufficient to equalize the internal and external pressures by opening the cock, removing the stopper, and pouring in cold water. The flask is then brought under a burette containing dilute $KMnO_4$ solution and the iron titrated without delay. With a carbonate which is wholly decomposable without the aid of heat, solution may be accomplished in a flask filled with CO_2, using cold acid, whereby the danger of attack of silicates is lessened if these are present. If the preference is for the $K_2Cr_2O_7$ method of titration, HCl may be used instead of H_2SO_4, in absence of manganese peroxide. In this case there is, of course, no separation of an insoluble calcium salt, a fact which renders easier the subsequent determination of the iron in any insoluble residue the rock may yield. The ferrous iron thus found is mostly, if not altogether, that existing as carbonate.[1]

(b) *In Presence of Carbonaceous Matter.*

Decomposition is effected in a flask by dilute H_2SO_4 in an atmosphere of CO_2. With limestones and active agitation no heat need be used, but with dolomites it will be necessary. The solution is then quickly filtered through asbestos (in an atmosphere of CO_2 if much iron is present), the residue and filter washed a few times with water, and the filtrate titrated at once with permanganate. If it is colored by organic matter, the result may be in error. As above, HCl and titration by $K_2Cr_2O_7$ may be used in absence of manganese peroxide. In either case it is important to allow the acid to act no longer than is necessary and to filter quickly. A determination of the ferrous iron in the insoluble matter is usually not worth attempting, because of the admixed organic matter.

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[1] If a determination of ferrous iron in the insoluble residue is desired see U. S. Geological Survey *Bulletin 700*, p. 265.

DETERMINATION OF AVAILABLE LIME.

Available Lime.

Place 1.4 g. of the carefully prepared and finely ground sample (passing 100 mesh) in a 400-cc. beaker, add 200 cc. of hot water, cover, heat carefully, then boil for three minutes.

Cool, wash down cover, add two drops of phenolphthalein and titrate with normal hydrochloric acid, adding the acid dropwise as rapidly as possible and stirring vigorously to avoid local excess of acid. When the pink color disappears in streaks, retard the rate of addition of acid somewhat, but continue until the pink color disappears entirely and does not reappear for 1 or 2 seconds. Note the reading and ignore the return of color.

Repeat the test, substituting for the 400-cc. beaker a 1-liter graduated flask, carrying a one-hole stopper fitted with a short glass tube drawn out to a point. Cool and add dropwise and with vigorous stirring a quantity of acid 5 cc. less than the amount added in the test previously made. Call the number of cubic centimeters used A. Grind up any small lumps with a glass rod flattened at one end, dilute to the mark with freshly boiled distilled water, close the flask with a solid stopper, mix thoroughly for 4 or 5 minutes and let settle for 30 minutes.

Pipette a 200-cc. portion, add phenolphthalein and titrate slowly with 0.5 N hydrochloric acid until the solution remains colorless on standing 1 minute. Call this additional number of cubic centimeters of acid B. Calculate the percentage of available CaO from the formula:

$$\text{Percentage of Available CaO} = 2A + 5B.$$

NOTES.

Results shall be reported on the non-volatile basis.

Standard acid solutions must be standardized by the Bureau of Standards benzoic acid No. 48-A. through a sodium hydroxide solution.

PREPARATION OF STANDARD SOLUTION OF POTASSIUM PERMANGANATE.

Potassium Permanganate.

Prepare a solution of potassium permanganate containing 5.64 g. of the pure crystallized salt in each liter. Such a solution will be of such strength that 1 cc. will approximately equal 0.005 g. of CaO (Note 25).

The best and simplest way to prepare such a solution is to weigh out the required quantity of potassium permanganate and place in a bottle containing the proper volume of water a week or ten days before the solution is to be standardized. The bottle and its contents must be kept in a dark place and shaken occasionally for the first three or four days. When ready for standardization, siphon off the solution through a glass siphon into another bottle, leaving a depth of about one inch of solution undisturbed in the original bottle (Note 26). Thoroughly mix the solution in the second bottle by shaking and standardize as follows (Note 27):

Dissolve 0.5 g. of $Na_2C_2O_4$ (Note 28) in a 400-cc. beaker with 200 to 250 cc. of hot water (80 to 90° C.) and add 10 cc. of dilute H_2SO_4 (1 : 1) to the solution. Titrate at once with the permanganate solution being standardized, stirring vigorously and continuously. The permanganate solution must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate solution necessary to give the end point color is determined by running a blank determination in another beaker containing the same volume of acid and water present in the original beaker, and heated to the same temperature (Note 29). The value of the permanganate solution in grams of CaO per cubic centimeter of solution may be calculated from the following equations:

$$5Na_2C_2O_4 + 2KMnO_4 + 8H_2SO_4 = 5Na_2SO_4 + K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O.$$

$$5CaC_2O_4 + 2KMnO_4 + 8H_2SO_4 = 5CaSO_4 + K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O.$$

NOTES.

1. Ignitions in electric muffles are far superior to flame ignitions. If an electric muffle is not available, flame ignition and the blast lamp may be used.

2. If a platinum dish is not available, porcelain may be used. A glass container positively must *not* be used.

3. Instead of strong acid, that of half strength may be used and the heating begun at once.

4. For ordinary control work in the plant laboratory this correction may, perhaps, be neglected; the double evaporation must never be neglected.

5. Fusion with pyrosulfate is to be avoided on account of the subsequent introduction of sulfates into the solution.

6. This precipitate may also contain TiO_2, P_2O_5, and Mn_3O_4.

7. Where the iron is present in small quantities it is rather unsatisfactory to determine it in the ignited oxides from the 0.5-g. sample. Under these conditions the alternative method may be used.

8. The pyrosulfates are less troublesome and more effective than the bisulfates.

9. This correction for impurities should not be made when the hydrofluoric acid correction of the main silica determination has been omitted. After two evaporations, 1 to 2 mg. of silica are still to be found with the R_2O_3 precipitate.

10. Zinc will also reduce titanium. If this metal is to be determined and deducted from Al_2O_3, then H_2S must be used for reduction (boiling out the H_2S in a stream of CO_2 before titration). If titanium is not to be determined, the slight error introduced by its reduction with zinc is so small as to be negligible except in the most exact and detailed analyses.

11. The gravimetric method must be employed when a recovery of aluminum is desired, or when a determination of strontium is contemplated.

12. Care must be exercised in this washing, as 1000 cc. of boiling water will dissolve over 1 cg. of CaC_2O_4.

13. The volumetric method may be used for ordinary control work in the plant laboratory. It must be borne in mind that in this method all strontium oxide is reported as calcium oxide.

14. Use not more than 125 cc. for this washing.

15. The less the amount of magnesium present, the longer the precipitate must be allowed to settle.

16. Made by diluting NH_4OH with distilled water until the solution contains 2½ per cent NH_3 by weight. Three or four drops of HNO_3 (sp. gr. 1.42) are then added.

17. When manganese is present in the limestone, it will be caught in large part with the magnesium precipitate. (See U. S. Geological Survey *Bulletin 700*, p. 134.) In case manganese was not eliminated before this precipitation, the weighed pyrophosphate must be dissolved in HNO_3, tested for manganese with bismuthate, the manganese determined and deducted as $Mn_2P_2O_7$.

18. This determination may be made if desired upon the 0.5-g. sample ignited for solution in HCl. See first page of these methods under "Treatment of Sample."

19. With burned lime and hydrated lime this determination may be omitted. Even when made in an atmosphere free from CO_2 the dried sample absorbs CO_2 sufficiently rapidly during weighing to make the result of questionable value.

20. Boiling for one minute is usually sufficient.

21. In limestones very low in phosphorus it may be deemed desirable to concentrate the phosphorus from a considerable weight of sample. In this case, proceed as directed by F. Hinden (*Zeitschr. Anal. Chemie*, Vol. 54, p. 214 (1915)), as follows: To the nitric acid solution of the large sample add a few drops of Fe_2Cl_6 solution and then NH_4OH until the liquid becomes slightly turbid. Then add 0.5 g. of pure precipitated $CaCO_3$ and boil for five minutes. Filter, dissolve the precipitate in dilute HNO_3 and proceed as above.

22. Titanium and vanadium, which interfere in this determination, should not be encountered in appreciable amounts in this class of material.

Instead of the specified alkalimetric titration method, the phosphorus in the phosphomolybdate may be determined as magnesium pyrophosphate (U. S. Geological Survey *Bulletin 700*, pp. 178–179), or by the reductor method (A. A. Blair, "Chemical Analysis of Iron," 8th Edition, pp. 91–92).

23. The persulfate method may be employed if desired.

24. The separation of manganese with the R_2O_3 precipitate by the use of bromine is not recommended on account of the incompleteness of the precipitation. Separation of manganese by means of ammonium sulfide after the ammonia precipitation is also undesirable on account of the introduction of the reagent and the slimy character of the precipitate.

See also Note 17 concerning the contamination of magnesium pyrophosphate by manganese pyrophosphate and the need of corrective measures when manganese is present in the material under analysis.

25. With high calcium limes, more than 50 cc. of this solution will probably be required to titrate the liberated oxalic acid. In such cases the use of a larger burette is to be preferred to increasing the strength of the permanganate solution.

26. The siphon should not extend nearer than 1 in. from the bottom of the original bottle.

27. This solution should be standardized at least once every week. It will be found more convenient to make a solution as above described and standardize it every week, than to attempt, by boiling and filtering, to make a solution which will not change.

28. Sodium oxalate for standardization of potassium permanganate solution should be purchased from the U. S. Bureau of Standards, Washington, D. C. This material is sold by the Bureau of Standards as Sample No. 40a.

29. When the end point is reached, the temperature of the solution should not be below 60° C.

TENTATIVE METHODS OF SAMPLING, INSPECTION, PACKING AND MARKING OF QUICKLIME AND LIME PRODUCTS.[1]

Serial Designation: C 50-22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. METHOD OF SAMPLING.

A. General.

General.

1. (*a*) All samples shall be taken in triplicate and immediately sealed in air-tight, moisture-proof containers.

(*b*) One sample shall be immediately delivered to the consignee; one sample shall be delivered to the consignor if requested within ten days from the date of sampling; the third sample shall be retained with seal unbroken until such time as the shipment has been accepted or a referee test called for.

(*c*) Samples shall be of an equal weight of not less than 5 lb. each when the shipment contains 30 tons or more. For smaller shipments, the weights of the samples may be reduced proportionately, provided that no sample shall weigh less than 2 lb. except by special agreement of the contracting parties.

(*d*) If the samples are taken at any place other than the place of manufacture of the material being sampled, such samples shall be taken within 24 hours of the receipt of the shipment.

(*e*) Sampling shall be conducted as expeditiously as possible in order to avoid undue exposure of the material to the air.

(*f*) Samples shall not be taken from broken packages.

B. Lump or Granular Material.

Lump or Granular Material in Bulk.

2. *In Bulk.*—Material shall be selected so that it will represent an average of all parts of the shipment, and shall not contain a disproportionate share of the top or bottom layers. This material shall comprise at least ten shovelfuls taken from different parts of the shipment. The total material so taken shall weigh not less than 100 lb. for a 30-ton shipment, with a proportionate quantity of material for shipments of other sizes, provided that at no time shall the total amount of material so taken weigh less than 50 lb. It shall be broken,

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

if necessary, to pass a 1-in. ring, thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared.

Lump or Granular Material in Packages.

3. *In Packages.*—At least 2 per cent of the packages shall be sampled, the packages to be taken from various parts of the shipment, and at no time shall less than 5 packages be sampled. The contents of each of the packages so taken shall be put in a pile, broken, if necessary, to pass a 1-in. ring, thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared.

C. *Powdered Material.*

Powdered Material, in Bulk.

4. *In Bulk.*—A sampling tube shall be used which takes a core of not less than 1 in. in diameter, and which is of sufficient length to permit the taking of a core from the top to the bottom of the mass being sampled. Cores shall be taken from at least 10 separate parts of the shipment. The cores so taken shall be thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared. A minimum quantity of 100 lb. shall be drawn for a shipment of 30 tons of material, with a proportionate quantity of material for shipments of other sizes provided that at no time shall less than 50 lb. be drawn as the original portion.

Powdered Material, in Packages.

5. *In Packages.*—A sampling tube shall be used which takes a core of not less than ½ in. in diameter. The tube shall be so inserted into the package that it shall pass substantially the entire length of the package; so as to take a core of the material being sampled from substantially the entire length of the package. Material thus taken from individual packages shall be thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared.

Individual packages shall be taken from various parts of the shipment. At least 1½ per cent of the packages shall be sampled, and at no time shall less than 5 packages be sampled.

D. *Treatment of Sample at Laboratory.*

Treatment at Laboratory.

6. To be supplied by the committee.

II. INSPECTION.

Inspection.

7. When inspection and sampling are to be conducted at the point of manufacture, the manufacturer shall afford the inspector representing the purchaser all reasonable facilities for inspection and sampling which shall be so conducted as not to interfere unnecessarily with the operation of the works.

III. REJECTION.

Rejection.

8. (*a*) Rejection of material based on failure to pass the tests prescribed in the specifications shall be reported within ten days from the taking of the samples, and the cause for rejection shall be stated.

(*b*) The samples which represent rejected material shall be kept in air-tight, moisture-proof containers for at least five days from the date of the original test report.

IV. RETESTING.

Retesting.

9. (*a*) Either of the contracting parties may make claim for a retest within five days of the date of the original test report. The expense of the retest shall be borne by the party demanding such retest.

(*b*) Should the contracting parties be unable to reach a mutually satisfactory agreement based upon the results of the original test, the third sample of material shall be delivered to a referee laboratory for test and the results of this referee test shall be binding on both parties.

V. PACKING.

Packing.

10. *Lump Lime.*—Lump lime may be shipped in bulk in carload lots, in wooden barrels or steel containers holding 180 lb. or 280 lb. net each, or in pasteboard cartons holding 90 lb. net each.

11. *Pulverized Lime.*—Pulverized lime may be shipped in bulk in carload lots, or in cloth or paper bags.

12. *Hydrated Lime.*—Hydrated Lime shall be shipped in cloth bags holding 100 lb. net each, or in paper bags holding 50 lb. net each.

VI. MARKING.

Marking.

13. Each shipment of material shall carry with it some means of identification, stating the particular contract on which the purchase and shipment were made.

14. Each package shall have legibly marked thereon, the net weight of its contents, the name of the manufacturer, the place of manufacture, and the brand name if any. This marking shall comply with all requirements of the Federal Lime Barrel Act, entitled "An Act to Standardize Lime Barrels (Public No. 228—Congress—S5425)," and with such other Federal or State laws as may be applicable to the shipment in question.

15. In addition to the above information, the following guarantee may be marked on each package or shipment: "Guaranteed by (name of manufacturer) to meet the specifications of the American Society for Testing Materials" for (name of material)."

TENTATIVE DEFINITIONS OF TERMS RELATING TO LIME.[1]

Serial Designation: C 51 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I.

Quicklime.—A calcined material, the major part of which is calcium oxide or calcium oxide in natural association with a lesser amount of magnesium oxide, capable of slaking with water.

Hydrated Lime.—A dry powder made by treating quicklime with enough water to satisfy its chemical affinity under the conditions of its hydration. It consists essentially of calcium hydroxide or of a mixture of calcium hydroxide and magnesium oxide and magnesium hydroxide.

II. SIZES OF QUICKLIME.

Lump Lime.—Quicklime as it comes from the kilns.

Lump Lime Screened.—Lump lime which has been screened or forked so that all of the pieces will be retained on a ½-in. sieve.

Pulverized Lime.—Lump lime which is of such size that it will all pass a No. 3 sieve.[2]

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. G. W. Hutchinson, Secretary of Committee C-7 on Lime, North Carolina State Highway Commission, Raleigh, N. C.

[2] See specifications for U. S. Standard Sieve Series in a publication now being prepared to supersede *Circular No. 39* of the U. S. Bureau of Standards.

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO THE GYPSUM INDUSTRY.[1]

Serial Designation: C 11 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1916; REVISED, 1921, 1922.

Accelerator.—The term accelerator shall apply to any material or substance which, when used in stucco, plaster, concrete, etc., will hasten set beyond the limit of testing error.

Aggregate.—The term aggregate shall refer to the inert material used as filler in stucco, plaster, mortar, concrete mixtures, etc., without regard to its function as a binding material.

Binder.—The term binder shall refer to any fibrous material which will increase the cohesiveness of plaster and stucco while in its plastic state.

Cement.—The term cement applies to any material, or a mixture of such materials (without aggregate) which, when in a plastic state, possesses adhesive and cohesive properties, and hardens in place. The word "cement" is used without regard to the composition of the material, and does not define its use or location as do the words "stucco," "plaster" and "mortar."

Consistency.—The term consistency is used to denote the degree of wetness of a plastic mixture.

Lath.—The term lath is used to designate a material whose primary function is that of a base or background for the reception of plaster or stucco. The word "lath" is used without regard to the composition of the material, defining only its use.

Mortar.—The term mortar applies to any material used in a plastic state that can be trowelled, and becomes hard in place, uniting such materials as brick, stone, tile, gypsum tile or blocks, terra cotta, etc., in building walls, partitions, columns, foundations, piers, floors, roof arches, etc. The word "mortar" is used without regard to the composition of the material, defining its use as a bonding material as contrasted with the words "stucco" and "plaster."

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[1] Criticisms of these Tentative Definitions are solicited and should be directed, preferably before January 1, 1923, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Washington St., Chicago, Ill.

Plaster.—The term plaster applies to any material used in a plastic state to form a hard covering for the interior surfaces, walls and ceilings, etc., of any building or structure. The word "plaster" is used without regard to the composition of the material, defining only its use and location of use as contrasted with the words "stucco" and "mortar."

Plasticity.—The term plasticity is used to denote the yielding property of a wet mixture to change of form.

Retarder.—The term retarder applies to any material or substance which, when used in stucco, plaster, mortar, concrete, etc., will retard set beyond the limit of testing error.

Stucco.—The term stucco refers to any material used in a plastic state to form a hard covering for the exterior walls or other exterior surfaces of any building or structure. The word "stucco" is used without regard to the composition of the material, defining only its use and location of use, as contrasted with the words "plaster" and "mortar."

Wood Fiber.—The term wood fiber applies to a material produced by grinding or shredding wood.

TENTATIVE RULES
FOR
INSPECTION OF CONCRETE AND REINFORCED CONCRETE WORK.[1]

Serial Designation: C 44 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Committee C-2 on Reinforced Concrete in presenting these Tentative Rules for Inspection of Concrete and Reinforced Concrete Work submits, as a guide in selecting the inspector, its recommendations as to his qualifications. These recommendations cannot, in fact, form a part of the rules.

QUALIFICATIONS OF AN INSPECTOR.

The inspector should have practical experience and an understanding of the fundamental engineering principles involved in the construction to which he is assigned; he preferably should have had technical training. The inspector should keep abreast of developments by reading the engineering and trade press, books and monographs on the subject and by attendance at meetings at which concrete work is discussed. Concrete and reinforced concrete construction is a rapidly-developing art and it is imperative that the inspector should be informed as to the most recent improvements, if he is to handle his work intelligently and efficiently.

STATUS OF INSPECTOR.

1. The word inspector as hereinafter used is a generic term. The inspector is the authorized representative of the engineer who is the authorized representative of the owner.

NOTE.—A grave responsibility rests on the inspector. The success of the construction may hinge on the proper performance of what may appear to be minor features of the work. In case of careless or faulty construction which results in loss of life the inspector may be charged with criminal negligence.

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[1] Criticisms of these Tentative Rules are solicited and should be directed, preferably before January 1, 1923, to Mr. Richard L. Humphrey, Chairman of Committee C-2 on Reinforced Concrete, 805 Harrison Building, Philadelphia, Pa.

RESPONSIBILITIES AND GENERAL DUTIES OF INSPECTOR.

2. It is the duty of the inspector to see that the work is executed in full accordance with the plans and specifications.

3. The inspector will be provided with complete plans and specifications for the work and shall familiarize himself with all their requirements.

NOTE.—The inspector should read and check off all dimensions and notes on the plans and list all special requirements in connection with the work to which they apply; when in doubt he should obtain instructions sufficiently in advance of the work to avoid delay.

4. The inspector shall familiarize himself with the Building Code or Regulations under which the work is being done, including all special rulings, which have a bearing on the type of construction under way.

NOTE.—The inspector should be familiar with auxiliary specifications and the common tests for suitability of the materials used in concrete and reinforced concrete work, such as:

(*a*) Standard Specifications and Tests for Portland Cement.
(*b*) Standard Specifications for Concrete Reinforcement Bars, etc.

5. The inspector shall be on the work at all times when it is in progress.

6. The inspector shall not permit work to proceed until requisite lines and levels have been established.

7. The inspector is authorized to:

(*a*) Forbid use of materials or workmanship which do not conform to specifications;
(*b*) Stop any work which is not being done in accordance with the plans and specifications;
(*c*) Require, with the approval of the engineer, the removal or repair of faulty construction.

8. The inspector shall immediately report to his immediate superior any action taken by him under Rule 7.

9. The inspector shall report at once to his immediate superior any discrepancies in plans or specifications that may come to his attention and request instructions.

10. The inspector shall not permit any departure from plans or specifications without written instructions from his immediate superior.

11. The inspector shall record and report daily the following information:

(*a*) Date;
(*b*) Location of work under way;
(*c*) Name of contractor;

(*d*) Delivery, installation, and removal of contractor's equipment;
(*e*) Number and classification of laborers, teams, plant, etc., in use;
(*f*) Materials received and on hand;
(*g*) Inspection and location of forms erected and completed reinforcement in place;
(*h*) Location and approximate quantities of concrete placed and bags of cement used;
(*i*) Time of commencement and completion of placing concrete;
(*j*) Number and location of samples taken;
(*k*) Nature and time of any control tests made;
(*l*) Forms removed;
(*m*) All items on force account work;
(*n*) Weather conditions, and temperature readings taken morning, noon and evening, including also the maximum and minimum temperatures during each preceding period;
(*o*) Material rejected or work condemned under Rule 7;
(*p*) Disposition of rejected materials;
(*q*) Any special instructions given to contractor;
(*r*) Any unusual features of the day's work;
(*s*) Signature of inspector.

NOTE.—It is not expected that the inspector shall act as time-keeper or materials clerk, but will record the data called for and, so far as possible, indicate the source of the information. For convenience, the inspector should be supplied with printed forms for daily reports.

12. The inspector shall procure, at the expense of the owner, photographs taken at frequent intervals to show the progress of the work.

13. The inspector, on force account work, shall check over with the authorized representative of the contractor, at the close of each day's work, all items included therein.

NOTE.—It is desirable to have printed forms on which the above can be reported daily and signed by the inspector and by the contractor's authorized representative.

EXCAVATION AND FOUNDATION.

14. The inspector shall examine the finished excavation and determine whether it is down to the level specified and see that the material on which the foundation is to rest is in accordance with the plans and specifications. If excavation is to go to rock he shall see that the surface of the rock is sound and completely exposed. He shall secure the approval of the engineer before permitting concrete to be placed.

15. The inspector shall see that the required number of piles are driven, each in its proper location and to the penetration required by the specifications.

16. The inspector shall check the piles in each group after driving and should report any pile which is materially out of line. He shall keep a record of:

(*a*) Method of driving;
(*b*) Type of pile;
(*c*) Length of pile;
(*d*) Diameter of pile;
(*e*) Total depth of penetration;
(*f*) Type and weight of hammer;
(*g*) Drop of hammer under last five blows;
(*h*) Penetration of pile under last five blows;
(*i*) Number of piles driven;
(*j*) Number of piles specified;
(*k*) Length of pile under cutoff.

17. The inspector shall see that there are no pockets in the concrete and that excessive laitance is removed.

18. The inspector shall see that the requirements of the specifications for placing concrete under water are strictly followed. In the absence of specifications, standard methods shall be used.

NOTE.—In placing concrete under water it is highly important that extra precautions be taken by the contractor to execute the work properly in order that the concrete may have adequate density, be free from segregations, or the washing out of any of the materials, and to avoid exposure of freshly deposited concrete to the water.

MATERIALS.

19. The inspector shall:

(*a*) Inspect and identify each lot of material upon its receipt on the work;
(*b*) Keep a careful watch of aggregates, especially if the source of supply is changed from time to time;
(*c*) See that aggregates are clean and properly graded.
(*d*) See that aggregates are free from vegetable or animal matter as determined by the colorimetric test described in the Standard Method of Test for Organic Impurities in Sands for Concrete (Serial Designation: C 40) of the American Society for Testing Materials.[1]
(*e*) See that materials are properly stored on the work.

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[1] **A.S.T.M. Standards Adopted in 1922.**

NOTE.—The cement should be properly piled and tagged; and housed in such a manner as to protect it from the weather.

Aggregates should be piled in such a manner as to insure them against intermingling of foreign materials.

Metal reinforcement should be stored preferably under shelter.

20. The inspector shall observe the following in selecting samples where tests of concrete materials are required under the specifications:

(*a*) Secure at least a 20-lb. sample of fine aggregate;
(*b*) Secure at least a 50-lb. sample of coarse aggregate;
(*c*) Give complete information concerning the sample (both on the inside and on the outside of the package);
(*d*) Samples shall be shipped in a strong sack or tight box; if a sack is used it shall be clean.

NOTE.—Tests on materials are worthless unless sampling is *properly* done. Particular care must be used in sampling aggregates under the following conditions:

(*a*) Aggregates in undeveloped pits;
(*b*) Coarse aggregate in cars or stock piles;
(*c*) Rock in native ledges.

NOTE.—The method of selecting test samples shall be as described in the Standard Methods of Sampling Stone, Slag, Gravel, Sand, and Stone Block for Use as Highway Materials (Serial Designation: D 75) of the American Society for Testing Materials.[1]

METAL REINFORCEMENT.

21. The inspector shall see that the metal reinforcement, before being positioned, is cleaned of mill and rust scale, and of coatings of any character that may destroy or reduce the bond. He shall reject reinforcement appreciably reduced in section. If there is delay in depositing concrete he shall re-inspect the reinforcement and when necessary shall see that it is cleaned.

22. The inspector shall see that the required bending of bars is uniformly and accurately done.

NOTE.—Bends can be more uniformly and accurately made by machine than by hand. In case a considerable number of bars are to be bent alike, it is advisable to bend one, put it in position and check the bends before bending the others, to insure proper location and degree of bends.

23. The inspector shall see that the reinforcement is of the specified size, bent in accordance with the specifications, and properly positioned in the forms before placing the concrete.

NOTE.—The inspector should not wait until the metal reinforcement has been wired substantially in place before passing on the correctness of its position, but should inspect the reinforcement during its placing.

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[1] A.S.T.M. Standards Adopted in 1922.

The inspector should inform himself as to the details for the placing of the reinforcement, especially as to size, length, bending, laps, and splices, and in case of doubt should secure instructions.

24. The inspector shall see that the bars are rigidly secured and that they are not displaced during the placing of the concrete.

25. The inspector shall see that all joints and splices in metal reinforcement are located and made in full accordance with the specifications.

MIXING AND PLACING OF CONCRETE.

26. The inspector, in order to secure the proportions and mixing required by the specifications, shall:

(*a*) Check the capacity of wheelbarrows or other measuring devices, and see that the method of loading them will secure uniformly the specified proportions;
(*b*) Record total quantities of cement and aggregates used;
(*c*) See that the specified consistency is maintained throughout the work;
(*d*) See that the time of mixing is that specified;
(*e*) See that changes in proportions and consistency, ordered by his immediate superior, are carried out;
(*f*) See that the samples required for tests of concrete are taken as provided in the Standard Method of Making and Storing Specimens of Concrete in the Field (Serial Designation: C 31) of the American Society for Testing Materials.[1]

27. The inspector shall see that the concrete is placed in accordance with the specifications, and specifically that:

(*a*) The method of conveying the concrete is as specified; or in the absence of specifications that it is such as to avoid segregation or the formation of excessive laitance;
(*b*) The concrete is placed in the form as near as possible to the point of its final location and is not permitted to flow long distances in the form;
(*c*) It is properly spaded or tamped so as to fill the forms and surround the reinforcement;
(*d*) It is properly spaded or forked to keep the coarse aggregate away from the forms so as to insure a smooth surface;

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[1] 1921 Book of A.S.T.M. Standards.

(*e*) The concrete is placed continuously without undue delay in each unit of the structure;

(*f*) Construction joints are made in accordance with the specifications; in the absence of specifications, that written instructions are obtained from his immediate superior.

(*g*) The concrete is poured in a continuous operation between construction joints;

(*h*) Where night work is necessary, adequate precautions as to lighting, etc., are taken;

(*i*) All anchor bolts, inserts, pipe sleeves, wiring, drainage pipes, flashings, conduits and other fixtures are in position as required by the plans and specifications before the concrete is placed; and that conduits and other equipment are built into the slab in such a manner as not to affect the position of metal reinforcement or weaken the member at critical sections;

(*j*) The specified precautions are strictly observed when it is necessary to place concrete in cold weather;

(*k*) A prompt report is made where conditions require additional fittings or where installations not called for in the specifications should be in position before the concrete is placed.

28. The inspector shall see that the freshly-placed concrete is protected and kept moist in accordance with the specifications.

NOTE.—Proper curing of the concrete is particularly important in floors or stairs where the concrete is not entirely covered by forms. This single precaution may add as much as 50 per cent to the crushing strength of concrete, greatly increase resistance to wear, and prevent "dusting" of floors.

FORMS.

29. The inspector shall examine the forms before placing concrete and:

(*a*) Check same as to location and dimensions:

(*b*) See that the surface of the form is oiled or wetted in accordance with the specifications;

(*c*) Report immediately any seeming lack of strength in forms which would permit bulging or sagging between supports;

NOTE.—This pressure amounts to over 100 lb. per sq. ft. of surface for each foot of depth, where the form is filled in forty minutes or less. It is very difficult and usually impossible with the equipment available to force a form back into position after it has shifted or sagged out of place while being filled.

(*d*) See that the column and girder forms are straight and properly aligned;

(*e*) See that foreign materials, such as chips, blocks, and shavings are removed from forms before concrete is placed.

REMOVAL OF FORMS.

30. The inspector shall see that the forms are removed:

(*a*) At the time and in the manner required;

(*b*) With care so as not to injure the structure or mar the surface of the concrete.

31. The inspector shall see that:

(*a*) The forms are not removed until the concrete has hardened sufficiently for safety;

(*b*) Special precautions are taken to protect the concrete during cold weather;

NOTE.—Concrete hardens very slowly at a temperature below 50° F. and setting action is scarcely perceptible at temperatures below 40° F. The time during which the concrete has been exposed to temperatures below 40° F. should be added to the periods stated in the schedule in determining the time of removal of forms. The effect of cold weather on the strength of concrete is well illustrated in *Bulletin 81* of the Engineering Experiment Station of the University of Illinois on "Influence of Temperature on the Strength of Concrete," by A. B. McDaniel.

(*c*) Any uncertainty as to the conditions affecting the removal of forms is promptly reported to his immediate superior;

(*d*) Defects in the surface of the concrete are repaired promptly upon the removal of forms;

(*e*) Heavy loading on green concrete is not permitted.

TENTATIVE SPECIFICATIONS
FOR
RAW TUNG OIL.[1]

Serial Designation: D 12 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. PROPERTIES AND TESTS.

Properties.

1. Raw tung oil shall conform to the following requirements:

	MAXIMUM.	MINIMUM.
Specific gravity at $\frac{15.5^\circ \text{ C}}{15.5^\circ}$	0.943	0.939
Acid number (Alcohol-Benzol)	7	.....
Saponification number	195	190
Unsaponifiable matter, per cent	0.75	.....
Refractive index at 25° C	1.520	1.515
Iodine number (Wijs)	.....	163
Heating test, minutes	12	....

II. METHODS OF TESTING.

SOLUTIONS REQUIRED.

Solutions Required.

2. The following reagents will be required:

Standard Sodium Thiosulfate Solution.—Dissolve pure sodium thiosulfate in distilled water that has been well boiled to free it from carbon dioxide in the proportion so that 24.83 g. crystallized sodium thiosulfate will be present in 1000 cc. of the solution. It is best to let this solution stand for about two weeks before standardizing. Standardize with pure resublimed iodine. (See Treadwell-Hall, *Analytical Chemistry*, Vol. II, third edition, p. 646.) This solution will be approximately N/10 and it is best to leave it as it is after determining its exact iodine value, rather than to attempt to adjust it to exactly N/10 strength. Preserve in a stock bottle with a guard tube filled with soda lime.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Purity of Raw Tung Oil (Serial Designation: D 12 - 16), 1921 Book of A.S.T.M. Standards.

Starch Solution.—Stir up 2 to 3 g. of potato starch or 5 g. soluble starch with 100 cc. of 1-per-cent salicylic acid solution, add 300 to 400 cc. boiling water, and boil the mixture until the starch is practically dissolved. Dilute to 1 liter.

Potassium Iodide Solution.—Dissolve 150 g. of potassium iodide free from iodate in distilled water and dilute to 1000 cc.

Iodine-Monochloride Solution.—Dissolve iodine in glacial acetic acid that has a melting point of 14.7 to 15° C. and is free from reducing impurities in the proportion so that 13 g. of iodine will be present in 1000 cc. of the solution. The preparation of the iodine-monochloride solution presents no great difficulty, but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine, over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. Set aside a small portion of this solution, while pure, and pass dry chlorine into the remainder until the halogen content of the whole solution is doubled. Ordinarily it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine, which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided.

Chloroform.—Should be U. S. P.

Standard Sodium Hydroxide Solution.—Prepare a stock concentrated solution of sodium hydroxide by dissolving NaOH in water in the proportion of 200 g. NaOH to 200 cc. water. Allow this solution to cool and settle in a stoppered bottle for several days. Decant the clear liquid from the precipitate of sodium carbonate into another clean bottle. Add clear barium hydroxide solution until no further precipitate forms. Again allow to settle until clear. Draw off about 175 cc. and dilute to 10 liters with freshly boiled distilled water. Preserve in a stock bottle provided with a large guard tube filled with soda lime. Determine the exact strength by titrating against pure benzoic acid (C_6H_5COOH) using phenolphthalein as indicator. (See Bureau of Standards *Scientific Paper No. 183.*) This solution will be approximately N/4, but do not attempt to adjust it to any exact value. Determine its exact strength and make proper corrections in using it.

Alcoholic Sodium Hydroxide Solution.—Dissolve pure NaOH in 95-per-cent ethyl alcohol in the proportion of about 22 g. per 1000 cc. Let stand in a stoppered bottle. Decant the clear liquid into another bottle, and keep well stoppered. This solution should be colorless or only slightly yellow when used; it will keep colorless longer if the alcohol is previously treated with NaOH (about 80 g. to 1000 cc.), kept at about 50° C. for 15 days, and then distilled. For an alternate method see *Journal,* American Chemical Society, 1906, p. 395.

Half Normal Sulfuric Acid Solution.—Add about 15 cc. H_2SO_4 (sp. gr. 1.84) to distilled water, cool and dilute to 1000 cc. Determine the exact strength by titrating against freshly standardized NaOH or by any other accurate method. Either adjust to exactly N/2 strength or leave as originally made, applying appropriate correction.

METHODS.

Methods of Testing.

3. The oil shall be tested in accordance with the following methods:

General.—The laboratory sample shall be thoroughly mixed by shaking, stirring, or pouring from one vessel to another and the samples for the individual tests taken from this thoroughly mixed sample.

Specific Gravity.—Use a pyknometer accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making the test at 15.5° C., water being 1 at 15.5° C.

Acid Number.—Weigh from 5 to 10 g. of the oil. Transfer to a 300-cc. Erlenmeyer flask. Add 50 cc. of a mixture of equal parts by volume of 95-per-cent ethyl alcohol and c. p. reagent benzol. (*This mixture should be previously titrated to a very faint pink with dilute alkali solution, using phenolphthalein as an indicator*). Add phenolphthalein indicator and titrate at once to a faint permanent pink color with the standard sodium hydroxide solution. Calculate the acid number (milligrams KOH per gram of oil).

Saponification Number.—Weigh about 2 g. of the oil in a 300-cc. Erlenmeyer flask. Add 25 cc. alcoholic sodium hydroxide solution. Put a condenser loop inside the neck of the flask and heat on the steam bath for one hour. Cool, add phenolphthalein as indicator, and titrate with N/2 H_2SO_4. Run two blanks with the alcoholic sodium hydroxide solution. These should check within 0.1 cc. N/2 H_2SO_4. From the difference between the number of cubic centimeters of N/2 H_2SO_4 required for the blank and for the determination, calculate the saponification number (milligrams KOH required for 1 g. of the oil).

Unsaponifiable Matter.—Weigh 8 to 10 g. of the oil. Transfer to a 250-cc. long-neck flask. Add 5 cc. of strong solution of sodium hydroxide (equal weights of NaOH and H_2O), and 50 cc. 95-per-cent ethyl alcohol. Put a condenser loop inside the neck of the flask and boil for two hours. Occasionally agitate the flask to break up the liquid but do not project the liquid onto the sides of the flask. At the end of two hours remove the condenser and allow the liquid to boil down to about 25 cc.

Transfer to a 500-cc. glass-stoppered separatory funnel, rinsing with water. Dilute with water to 250 cc., add 100 cc. redistilled ether. Stopper and shake for one minute. Let stand until the two layers separate sharp and clear. Draw all but one or two drops of the aqueous layer into a second 500-cc. separatory funnel and repeat the process, using 60 cc. of ether. After thorough separation draw off the aqueous solution into a 400-cc. beaker, then the ether solution into the first separatory funnel, rinsing down with a little water. Return the aqueous solution to the seond separatory funnel and shake out again with 60 cc. of ether in a similar manner, finally drawing the aqueous solution into the beaker and rinsing the ether into the first separatory funnel.

Shake the combined ether solution with the accumulated water rinsings and let the layers separate sharp and clear. Draw off the water and add it to the main aqueous solution. Shake the ether solution with two portions of water (about 25 cc. each). Add these to the main water solution.

Swirl the separatory funnel so as to bring the last drops of water down to the stopcock, and draw off until the ether solution just fills the bore of the stopcock. Wipe out the stem of the separatory funnel with a bit of cotton on a wire. Draw the ether solution (portionwise if necessary) into a 250-cc. flask and distill off. While still hot, drain the flask into a small weighed beaker, rinsing with a little ether. Evaporate this ether, cool and weigh.

NOTE.—The unsaponifiable oil from adulterated drying oils is volatile and will evaporate on long heating. Therefore heat the beaker on a warm plate, occasionally blowing out with a current of dry air. Discontinue heating as soon as the odor of ether is gone.

Refractive Index.—Use a properly standardized Abbé refractometer at 25° C., or any other equally accurate instrument.

Iodine Number.—Place a small quantity of the sample in a small weighing burette or beaker. Weigh accurately. Transfer by dropping from 0.16 to 0.19 g. to a 500-cc. bottle having a well-ground glass stopper, or an Erlenmeyer flask having a specially flanged neck for the iodine tests. Reweigh the burette or beaker and determine the amount of sample used. Add 10 cc. of chloroform. Whirl the bottle to dissolve the sample. Add 10 cc. of chloroform to each of two empty bottles like that used for the sample. Add to each bottle 25 cc. of the

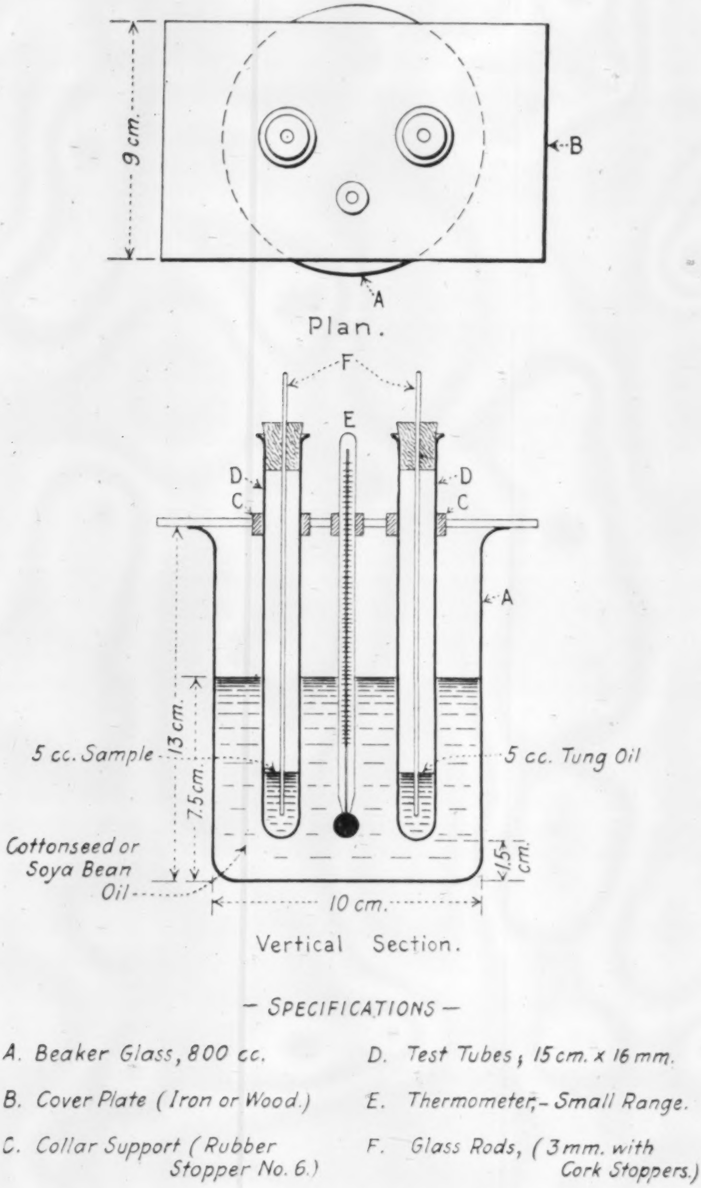
9 cm.
B
A
Plan.
F
E
D
D
C
C
A
13 cm.
7.5 cm.
5 cc. Sample
5 cc. Tung Oil
Cottonseed or Soya Bean Oil
1.5 cm.
10 cm.
Vertical Section.
– SPECIFICATIONS –
A. Beaker Glass, 800 cc.
B. Cover Plate (Iron or Wood.)
C. Collar Support (Rubber Stopper No. 6.)
D. Test Tubes; 15 cm. x 16 mm.
E. Thermometer, - Small Range.
F. Glass Rods, (3 mm. with Cork Stoppers.)

FIG. 1.—Tung Oil Heat Test Apparatus (Revised 1920).

NOTE: Collars C may be omitted and tubes supported in present place by aid of wire gauze placed in bottom of oil bath and resting on bottom of beaker.

Wijs solution and let stand with occasional shaking for 30 minutes in a dark place at a temperature of from 21 to 23° C. Add 10 cc. of the 15-per-cent potassium iodide solution and 100 cc. of water, and titrate with standard sodium thiosulfate using starch as the indicator. The titrations on the two blank tests should agree within 0.1 cc. From the difference between the average of the blank titration and the titration on the samples and the iodine value of the thiosulfate solution, calculate the iodine number of the samples tested. (Iodine number is given in centigrams of iodine to 1 g. of sample.)[1]

Heating Test.—Test tubes containing the oil should be 15 cm. by 16 mm., with a mark near the bottom to indicate 5 cc., and closed by a cork so perforated that a glass rod 3 mm. in diameter can move freely.

Fill an 800-cc. glass beaker (height, 13 cm.; diameter, 10 cm.). with cottonseed oil or soya bean oil to a height of 7.5 cm. Place a thermometer so as to be 1.5 cm. from the bottom of the bath. (See Fig. 1.)

Use a nitrogen-filled, chemical thermometer; engraved stem; total length 4 to 4½ in., graduated from 210 to 310° C. in 2° intervals; the length between 210 and 310° C. not less than 2½ in. Thermometer glass shall be well annealed.

When the bath temperature is 293° C. (560° F.) and very slowly rising at this point, place the tube containing 5 cc. of the oil to be tested and the tube containing 5 cc. of a control sample of known value, so that the bottom of each tube is level with the lowest part of the bulb of the thermometer. If desired, the collars *C* may be omitted and the tubes allowed to rest upon a piece of wire gauze placed in the bottom of the oil bath so that the tubes will be 1.5 cm. from the bottom of the bath. Note the time. Remove the source of heat for about 45 seconds and then reapply. Before 2 minutes have elapsed the temperature of the bath will have fallen to 282° C. (530° F.), at which point it should be kept as steady as possible. When the samples have been in the bath 9 minutes, raise the glass rods at intervals of ¼ minute. Note the time when each sample becomes firmly set. At this period the oil will be so stiff that the entire tube may be lifted by aid of the rod if the collar *C* is omitted from the apparatus. As setting or jellying takes place within a few seconds of fluidity, a good end determination is afforded. Remove the specimens. Heat the bath again to 293° C., and repeat the experiment with fresh portions of the sample.

No stirrer is used in the bath. A screen around the bath enables the temperature to be more easily reached. When the bath oil has become tarry and viscid, it should be renewed; otherwise heating may be irregular.

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[1] It is always well to include a test on a sample of tung oil of known iodine value. This may be kept in a dark-colored bottle as a standard

TENTATIVE SPECIFICATIONS
FOR
SOYA BEAN OIL, RAW OR REFINED.[1]

Serial Designation: D 124 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. PROPERTIES AND TESTS.

Properties.

1. Soya bean oil, raw or refined, shall conform to the following requirements:

	MAXIMUM.	MINIMUM.
Foots, per cent	2.5	...
Loss on heating at 105 to 110° C., per cent	0.2	...
Specific gravity at 15.5°/15.5° C	...	0.924
Acid number	5.0	...
Saponification number	...	190
Iodine number (Hanus)	...	128
Unsaponifiable matter, per cent	1.5	...
Color	Not darker than a freshly prepared solution of 1.0 g. potassium bichromate in 100 cc. pure H_2SO_4 (sp. gr. 1.84).	

II. METHODS OF TESTING.

SOLUTIONS REQUIRED.

Solutions Required.

2. The following reagents will be required:

Acetone that will pass the specification of the United States Pharmacopoeia.

Acid Calcium Chloride Solution.—Saturate with calcium chloride a mixture of 90 parts water and 10 parts HCl (sp. gr. 1.18).

Standard Sodium Thiosulfate Solution.—Dissolve pure sodium thiosulfate in distilled water that has been well boiled to free it from carbon dioxide in the proportion so that 24.83 g. crystallized sodium thiosulfate will be present in 1000 cc. of the solution. It is best to let this solution stand for about two weeks before standardizing. Standardize with pure resublimed iodine. (See Treadwell-Hall, *Analytical Chemistry*, Vol. II, third edition, p. 646.) This solution will be approximately N/10 and it is best to leave it as it is after determining its exact iodine value, rather than to attempt to adjust it to exactly N/10 strength. Preserve in a stock bottle with a guard tube filled with soda lime.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York Street, Brooklyn, N. Y.

Starch Solution.—Stir up 2 to 3 g. of potato starch or 5 g. soluble starch with 100 cc. of 1-per-cent salicylic acid solution, add 300 to 400 cc. boiling water, and boil the mixture until the starch is practically dissolved. Dilute to 1 liter.

Potassium Iodide Solution.—Dissolve 150 g. of potassium iodide free from iodate in distilled water and dilute to 1000 cc.

Hanus Solution.—Dissolve 13.2 g. of iodine in 1000 cc. of glacial acetic acid (99.5-per-cent) that will not reduce chromic acid. Add enough bromine to double the halogen content, determined by titration (3 cc. of bromine is about the proper amount). The iodine may be dissolved by the aid of heat, but the solution should be cold when the bromine is added.

Standard Sodium Hydroxide Solution.—Prepare a stock concentrated solution of sodium hydroxide by dissolving NaOH in water in the proportion of 200 g. NaOH to 200 cc. water. Allow this solution to cool and settle in a stoppered bottle for several days. Decant the clear liquid from the precipitate of sodium carbonate into another clean bottle. Add clear barium hydroxide solution until no further precipitate forms. Again allow to settle until clear. Draw off about 175 cc. and dilute to 10 liters with freshly boiled distilled water. Preserve in a stock bottle provided with a large guard tube filled with soda lime. Determine the exact strength by titrating against pure benzoic acid (C_6H_5COOH) using phenolphthalein as indicator. (See Bureau of Standards *Scientific Paper No. 183.*) This solution will be approximately N/4, but do not attempt to adjust it to any exact value. Determine its exact strength and make proper corrections in using it.

Alcoholic Sodium Hydroxide Solution.—Dissolve pure NaOH in 95-per-cent ethyl alcohol in the proportion of about 22 g. per 1000 cc. Let stand in a stoppered bottle. Decant the clear liquid into another bottle, and keep well stoppered. This solution should be colorless or only slightly yellow when used; it will keep colorless longer if the alcohol is previously treated with NaOH (about 80 g. to 1000 cc.), kept at about 50° C. for 15 days, and then distilled. For an alternate method see *Journal*, American Chemical Society, 1906, p. 395.

Half Normal Sulfuric Acid Solution.—Add about 15 cc. H_2SO_4 (sp. gr. 1.84) to distilled water, cool and dilute to 1000 cc. Determine the exact strength by titrating against freshly standardized NaOH or by any other accurate method. Either adjust to exactly N/2 strength or leave as originally made, applying appropriate correction.

METHODS.

Methods of Testing.

3. The oil shall be tested in accordance with the following methods:

General.—The laboratory sample shall be thoroughly mixed by shaking, stirring, or pouring from one vessel to another and the samples for the individual tests taken from this thoroughly mixed sample.

Loss on Heating at 105 to 110° C.—Place 10 g. of the oil in an accurately weighed 200-cc. Erlenmeyer flask; weigh. Heat in an oven at a temperature between 105 and 110° C. for 30 minutes; cool and weigh. Calculate the percentage loss. This determination shall be made in a current of dry carbon dioxide gas.

Foots.—With all materials at a temperature between 20 and 27° C., mix, by shaking in a stoppered flask for exactly one minute, 25 cc. of the well-shaken sample of oil, 25 cc. of acetone and 10 cc. of the acid calcium chloride solution. Transfer the mixture to a burette where settling can take place for 24 hours. The temperature during this period should be between 20 and 27° C.

The volume of the stratum lying between the clear calcium chloride solution and the clear acetone and oil mixture is read in tenths of a cubic centimeter or a fraction thereof. This reading multiplied by four expresses the amount of foots present as percentage by volume of the oil taken.

Specific Gravity.—Use a pyknometer accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making the test at 15.5° C., water being 1 at 15.5° C.

Acid Number.—Weigh from 5 to 10 g. of the oil. Transfer to a 300-cc. Erlenmeyer flask. Add 50 cc. of neutral 95-per-cent ethyl alcohol. Put a condenser loop inside the neck of the flask. Heat on a steam bath for 30 minutes. Cool and add phenolphthalein indicator. Titrate to a faint permanent pink color with the standard sodium hydroxide solution. Calculate the acid number (milligrams KOH per gram of oil).

Saponification Number.—Weigh about 2 g. of the oil in a 300-cc. Erlenmeyer flask. Add 25 cc. alcoholic sodium hydroxide solution.

Put a condenser loop inside the neck of the flask and heat on the steam bath for one hour. Cool, add phenolphthalein as indicator, and titrate with N/2 H_2SO_4. Run two blanks with the alcoholic sodium hydroxide solution. These should check within 0.1 cc. N/2 H_2SO_4. From the difference between the number of cubic centimeters of N/2 H_2SO_4 required for the blank and for the determination, calculate the saponification number (milligrams KOH required for 1 g. of the oil).

Unsaponifiable Matter.—Weigh 8 to 10 g. of the oil. Transfer to a 250-cc. long-neck flask. Add 5 cc. of strong solution of sodium hydroxide (equal weights of NaOH and H_2O), and 50 cc. 95-per-cent ethyl alcohol. Put a condenser loop inside the neck of the flask and boil for two hours. Occasionally agitate the flask to break up the liquid but do not project the liquid onto the sides of the flask. At the end of two hours remove the condenser and allow the liquid to boil down to about 25 cc.

Transfer to a 500-cc. glass-stoppered separatory funnel, rinsing with water. Dilute with water to 250 cc., add 100 cc. redistilled ether. Stopper and shake for one minute. Let stand until the two layers separate sharp and clear. Draw all but one or two drops of the aqueous layer into a second 500-cc. separatory funnel and repeat the process using 60 cc. of ether. After thorough separation draw off the aqueous solution into a 400-cc. beaker, then the ether solution into the first separatory funnel, rinsing down with a little water. Return the aqueous solution to the second separatory funnel and shake out again with 60 cc. of ether in a similar manner, finally drawing the aqueous solution into the beaker and rinsing the ether into the first separatory funnel.

Shake the combined ether solution with the accumulated water rinsings and let the layers separate sharp and clear. Draw off the water and add it to the main aqueous solution. Shake the ether solution with two portions of water (about 25 cc. each). Add these to the main water solution.

Swirl the separatory funnel so as to bring the last drops of water down to the stopcock, and draw off until the ether solution just fills the bore of the stopcock. Wipe out the stem of the separatory funnel with a bit of cotton on a wire. Draw the ether solution (portionwise if necessary) into a 250-cc. flask and distill off. While still hot, drain the flask into a small weighed beaker, rinsing with a little ether. Evaporate this ether, cool and weigh.

NOTE.—The unsaponifiable oil from adulterated drying oils is volatile and will evaporate on long heating. Therefore heat the beaker on a warm plate, occasionally blowing out with a current of dry air. Discontinue heating as soon as the odor of ether is gone.

Hanus Iodine Number.—Place a small quantity of the sample in a small weighing burette or beaker. Weigh accurately. Transfer by dropping about 0.15 g. (0.10 to 0.20 g.) to a 500-cc. bottle having a well-ground glass stopper, or an Erlenmeyer flask having a specially flanged neck for the iodine test. Reweigh the burette or beaker and determine the amount of sample used. Add 10 cc. of chloroform. Whirl the bottle to dissolve the sample. Add 10 cc. of chloroform to each of two empty bottles like that used for the sample. Add to each bottle 25 cc. of the Hanus solution and let stand with occasional shaking for one-half hour. Add 10 cc. of the 15-per-cent potassium iodide solution and 100 cc. of water; and titrate with standard sodium thiosulfate using starch as indicator. The titrations on the two blank tests should agree within 0.1 cc. From the difference between the average of the blank titration and the titration on the samples and the iodine value of the thiosulfate solution, calculate the iodine number of the samples tested. (Iodine number is centigrams of iodine to 1 g. of sample.)

Color.—Prepare a fresh solution of pure potassium bichromate in pure colorless H_2SO_4 (sp. gr. 1.84). This solution should be in the proportion of 1.0 g. potassium bichromate to 100 cc. (184.0 g.) H_2SO_4. Place the oil and colored solution in separate thin-walled, clear glass tubes of the same diameter (1 to 2 cm.) to a depth of not less than 2.5 cm. and compare the depths of color by looking transversely through the columns of liquid by transmitted light.

TENTATIVE SPECIFICATIONS
FOR
PERILLA OIL, RAW OR REFINED.[1]

Serial Designation: D 125 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. PROPERTIES AND TESTS.

Properties.

1. Perilla oil, raw or refined, shall conform to the following requirements:

	MAXIMUM.	MINIMUM.
Foots, per cent.	2.5	...
Loss on heating at 105 to 110° C., per cent.	0.2	...
Specific gravity at 15.5°/15.5° C.	...	0.932
Acid number	5.0	...
Saponification number	...	190
Iodine number (Hanus)	...	191
Unsaponifiable matter, per cent.	1.5	..
Color	Not darker than a freshly prepared solution of 1.0 g. potassium bichromate in 100 cc. pure H_2SO_4 (sp. gr. 1.84).	

II. METHODS OF TESTING.

Methods of Testing.

2. The oil shall be tested in accordance with the methods described in Sections 2 and 3 of the Tentative Specifications for Soya Bean Oil, Raw or Refinea (Serial Designation: D 124 – 22 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specificatons are solicited and should be directed, preferably before January 1, 1923, to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York Street, Brooklyn, N. Y.

[2] See p. 748.

TENTATIVE METHODS OF ROUTINE ANALYSIS OF YELLOW AND ORANGE PIGMENTS CONTAINING CHROMIUM COMPOUNDS, BLUE PIGMENTS AND CHROME GREEN.[1]

Serial Designation: D 126 - 22 T.

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Issued, 1922.

GENERAL METHODS.

Specific Gravity.

Specific Gravity. 1. True specific gravity shall be determined by Thompson's method,[2] or by means of a 50-cc. pyknometer, using c. p. benzene, or by Gardner's method.[3]

Tinting Strength.[4]

Tinting Strength. 2. The colors should always be compared with a carefully selected standard. Weigh out accurately a portion of the color (0.05 g. of yellow or green; 0.01 of blue), place on a large glass plate, add 12 drops of bleached linseed oil[5] (24 drops with blues), and rub up with a flat-bottomed glass pestle or muller; add pure ZnO (1 g. for yellows or greens, 2 g. for blues), and grind with a circular motion 50 times; gather up with a sharp-edged spatula and grind out twice more in like manner, giving the pestle a uniform pressure. Next weigh out a similar amount of the standard, and treat in exactly the same manner as described above. Transfer portions of each paste to a microscope slide, quite close together, and then draw a palette knife across both samples so as to make them meet in a line (differences in tint are then easily seen). Compare the tints as shown on both sides of the glass. The amount of pigment used will vary with the tinting strength, but the amounts indicated will generally suffice.

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[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIII, p. 407 (1913).

[3] *Circular No. 104* (Sept., 1920), Educational Bureau, Paint Manufacturers' Association of the U. S.

[4] Holley, "Analysis of Paint and Varnish Products," 1912, p. 126.

[5] The use of "oxidized" oil should be avoided (oil that has become "fatty" by standing in a can or bottle). Poppy oil could be used but it is quite as necessary to have it reasonably fresh as when linseed oil is used. In either case "stringy" pastes are not reliable.

If it is desired to express quantitatively the tinting strength of the pigment, consider the standard pigment as having a tinting strength of 100, and then vary the amount of the standard pigment until the tints are matched.

For example, let the amount of standard pigment for 100 strength test be 0.05 g. (= A). Vary this amount in units of 5 per cent, thus 0.0475 or 0.0525. Let the amount required to match a given strength equal B, then

$$\frac{B}{A} \times 100$$

equals the tinting strength of the sample to be tested.

If the tone varies it may be difficult to make this measurement.

ADDED COLORING MATTER.

Added Coloring Matter.

3. Test the pigment successively with hot water, 95-per-cent ethyl alcohol, and chloroform. The solutions should remain colorless. Other reagents may be tried.[1]

METHODS OF ANALYSIS OF YELLOW AND ORANGE PIGMENTS.

CHROME YELLOWS, AMERICAN VERMILION, BASIC LEAD CHROMATE.

A pure chrome yellow should contain only lead chromate and other insoluble lead compounds.

MOISTURE.

Moisture.

4. Heat 2 g. at 105° C. for two hours. The loss in weight is reported as moisture.

INSOLUBLE MATTER.

Insoluble Matter.

5. Treat 1 g. with 25 cc. of concentrated HCl and boil for from 5 to 10 minutes in a covered beaker, adding about 6 drops of alcohol to the boiling liquid, one at a time. Dilute to 100 cc. with hot water and boil for from 5 to 10 minutes (the solution should be complete). Filter the hot solution (if insoluble matter is present) and wash with boiling water till washings are free from lead and chlorine. Ignite the insoluble matter, weigh, and examine for SiO_2, $BaSO_4$, and Al_2O_3.

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[1] For details consult Zerr, "Tests for Coal-Tar Colors in Aniline Lakes" (English translation by C. Mayer); Schultz and Julius, "A Systematic Survey of the Organic Coloring Matters;" Hall, "The Chemistry of Paints and Paint Vehicles;" and Mulliken, "Identification of Pure Organic Compounds," *Commercial Dyestuffs*, Vol. III.

TOTAL LEAD.

Total Lead. 6. Nearly neutralize with NH_4OH the filtrate from the insoluble matter (or the original solution), dilute to about 300 cc., and pass into the clear solution a rapid current of H_2S until all of the lead is precipitated as PbS. Let the precipitate settle, filter, wash with water containing some H_2S. Boil the filter and precipitate with dilute HNO_3 until all of the lead has dissolved, filter, and wash thoroughly with hot water. To the filtrate, add 10 cc. of H_2SO_4 (1 : 1), evaporate until copious fumes of SO_3 are evolved, cool, add about 75 cc. of H_2O and then 75 cc. of 95-per-cent ethyl alcohol. Let stand about one hour, filter on a Gooch crucible, wash with dilute alcohol, dry, ignite, and weigh as $PbSO_4$.

CHROMIUM (IRON, ALUMINUM).

Chromium. 7. Heat the filtrate from the PbS to expel H_2S and, if iron is present, add a few drops of HNO_3 and boil about two minutes. Render the solution just alkaline with NH_4OH, boil a few minutes, filter, and wash with hot 2-per-cent NH_4Cl solution. (If the sample contains an appreciable amount of zinc, a double precipitation should be made.) In the absence of iron and aluminum this precipitate may be ignited and weighed as Cr_2O_3. If iron and aluminum are present, dissolve the NH_4OH precipitate with hot dilute HCl, washing the paper with hot water; *cool*, add NH_4OH until alkaline, and then add Na_2O_2 (about 1 g), keeping the beaker covered. Digest until all of the chromium and aluminum has been dissolved, adding more Na_2O_2 if necessary. Filter off the $Fe(OH)_3$, wash thoroughly with hot water, ignite and weigh as Fe_2O_3; or, dissolve the precipitate in HCl and determine the Fe content volumetrically. Make up the filtrate from the $Fe(OH)_3$ to 250 cc. in a graduated flask, and mix. Render an aliquot portion acid with H_2SO_4, boil to expel any free oxygen, cool, add an excess of standard $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$ solution and titrate back with 0.1 *N* $K_2Cr_2O_7$ solution, using $K_3Fe(CN)_6$ as outside indicator. (The CrO_3 may also be determined by acidifying the aliquot portion with acetic acid, preciptating as $PbCrO_4$ or $BaCrO_4$, and finally weighing on a Gooch crucible.) To determine Al_2O_3, make an aliquot portion of the filtrate from the $Fe(OH)_3$ acid with HCl, and then just distinctly alkaline with NH_4OH, heat to boiling, let settle, filter, wash with hot 2-per-cent NH_4Cl solution, ignite and weigh as Al_2O_3. If iron and aluminum are not to be determined or are present in negligible amounts, the first NH_4OH precipitate may be dissolved in dilute HCl, oxidized with Na_2O_2, acidified with H_2SO_4, boiled, and CrO_3 determined volumetrically. The CrO_3 in the absence of other oxidizing substances, may be determined on 1 g. of the pigment by Schwartz' method (Fresenius Quantitative Chemical Analysis, Ed. 6, Vol. 1, p. 424).

ZINC, CALCIUM, AND MAGNESIUM.

Zinc, Calcium, Magnesium.

8. Precipitate any zinc in the filtrate from the first NH_4OH precipitate with H_2S, filter, wash with dilute $(NH_4)_2S$, dissolve the zinc sulfide in dilute HCl, and determine the Zn content volumetrically by $K_4Fe(CN)_6$ method. In the filtrate from the zinc sulfide, determine calcium by the oxalate method and magnesium as $Mg_2P_2O_7$.

SULFURIC ANHYDRIDE.

Sulfuric Anhydride.

9. Heat 1 g. of the pigment with 10 cc. of concentrated HCl until free chlorine is expelled, add about 300 cc. of water and boil; filter off any insoluble matter and wash thoroughly with hot water, heat to boiling, and precipitate with $BaCl_2$ solution in the usual manner. Keep the solution hot while filtering off the $BaSO_4$ and wash with hot water until the washings show no lead or chlorine.

CARBON DIOXIDE.

Carbon Dioxide.

10. Determine carbon dioxide by the evolution method, using dilute HNO_3, free from oxides of nitrogen.

WATER-SOLUBLE MATTER.

Water-Soluble Matter.

11. Weigh 5 g. of the pigment on to a weighed Gooch crucible (containing asbestos, and dried at 110° C.), wash six times with 25-cc. portions of cold water; dry at 110° C. and weigh. The loss in weight, corrected for moisture (as determined above), represents the soluble salts removed by the water. The washings may be examined, if desired.

ADDED COLORING MATTER AND TINTING STRENGTH.

Coloring Matter.

12. Make the test for added coloring matter and tinting strength in accordance with Section 3.

CALCULATIONS.

Calculations.

13. Calculate CrO_3 to $PbCrO_4$, and SO_3 to $PbSO_4$ if calcium is absent. If CO_2 is present and calcium and magnesium are absent, calculate to $(PbCO_3)_2 \cdot Pb(OH)_2$. Report any residual Pb as PbO. If calcium is present, calculate to $CaCO_3$ if CO_2 is also present. If calcium and SO_3 are present and CO_2 is absent, calculate to $CaSO_4$. If calcium, CO_2, and SO_3 are present, calculate to $CaCO_3$; any residual calcium is then calculated to $CaSO_4$. Report zinc as ZnO.

METHODS OF ANALYSIS OF BLUE PIGMENTS.

IRON CYANIDE BLUES. (PRUSSIAN BLUE, CHINESE BLUE, ANTWERP BLUE, MILORI BLUE, BRONZE BLUE, STEEL BLUE.)

The analysis of these blues, as is generally the case with pigments, does not necessarily give results which can be used to grade samples, the strength and color tests being most important.

MOISTURE.

Moisture.

14. Heat 2 g. of the pigment at 105° C. for two hours. The loss in weight is reported as moisture. A "dry" Prussian blue should contain less than 7 per cent of moisture.

INSOLUBLE MATTER.

Insoluble Matter.

15. Ignite 1 g. of the pigment in a porcelain dish at a low temperature, just high enough to decompose the last trace of blue, but not high enough to render the iron difficultly soluble in HCl. Cool, add 15 cc. of HCl and a few drops of bromine, cover with a watch glass, and digest on the steam bath; wash off cover, evaporate to a syrup, add water, boil, filter, wash with hot water, ignite the residue and weigh. Examine the insoluble residue for silica, barium sulfate, and alumina. A pure Prussian blue should show no insoluble residue.

IRON AND ALUMINUM.

Iron and Aluminum.

16. Determine iron and aluminum in the filtrate from the insoluble matter by precipitation with NH_4OH in the usual manner. A double precipitation is desirable. Ignite and weigh $Fe_2O_3+Al_2O_3$, deduct Fe_2O_3 (calculated from total Fe), and calculate Al_2O_3 to Al.

CALCIUM.

Calcium.

17. Determine calcium in the filtrate from the $Fe_2O_3+Al_2O_3$ by precipitation with ammonium oxalate; titrate with $KMnO_4$, or, ignite and weigh as CaO. Acidify the filtrate from the calcium oxalate with HCl and dilute to a definite volume and mix.

SULFURIC ACID.

Sulfuric Acid.

18. Determine sulfuric acid in an aliquot of the above solution as $BaSO_4$ in the usual manner.

ALKALI METAL AND ALKALINE SALTS.

Alkali.

19. Evaporate an aliquot of the above solution with sulfuric acid, ignite (treating with solid ammonium carbonate), and weigh. Determine whether the alkali metal is sodium or potassium and subtract the alkali metal corresponding to the sulfate (SO_4) found. The remainder is alkali combined with the blue and is reported as Na or K.

TOTAL IRON.

Total Iron.

20. Decompose and dissolve 1 g. of the pigment as under "Insoluble Matter," reduce, and determine the total iron with $KMnO_4$ or $K_2Cr_2O_7$. There should be not less than 30 per cent, calculated on the dry pigment.

TOTAL NITROGEN.

Total Nitrogen.

21. Determine the total nitrogen on a 1-g. sample of the pigment by the Kjeldahl-Gunning Method, digesting for at least 2½ hours. The sulfuric acid should not blacken, which would indicate organic adulteration.

WATER-SOLUBLE MATTER.

Water-Soluble Matter.

22. Weigh 2.5 g. of the pigment into a graduated 250-cc. flask, add 100 cc. of water, and boil for five minutes. Dilute with water, let stand until at room temperature, make up to mark, mix and let settle. Filter through dry paper and discard the first 25 cc. Transfer 100 cc. of the clear filtrate to a weighed dish, evaporate to dryness on a steam-bath, dry in an oven at 105° C. for 30 minutes, cool, and weigh.

ADDED COLORING MATTER AND TINTING STRENGTH.

Coloring Matter.

23. Make the test for added coloring matter and tinting strength in accordance with Section 3, omitting the treatment with hot water. Also test the pigment with dilute acid for ultramarine blue (evolution of hydrogen sulfide) and carbonates (evolution of carbon dioxide).

CALCULATIONS.

Calculations.

24. The percentage of Prussian blue may be obtained with sufficient accuracy for commercial purposes by multiplying the percentage of nitrogen by 4.4 or the percentage of iron (in the absence of other iron pigments) by 3.03[1].

NOTE.—Some blues, *e. g.*, Chinese blue, may contain tin salts. Others may contain manganese or chromium compounds. The presence of these compounds should be determined by a qualitative examination at least.

METHODS OF ANALYSIS OF ULTRAMARINE BLUE.

An analysis is of little value for determining the quality of pure ultramarines, but is useful in the identification of foreign admixtures. Practical tests as to the stability and compatability of the pigment in mixtures with other pigments, coloring power, tint, fineness, fastness to light, etc., are more important than chemical analysis.

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[1] Parry and Coste, *The Analyst*, Vol. 21, pp. 225 to 230 (1896).

MOISTURE.

Moisture.

25. Heat 2 g. of the pigment at 105° C. for two hours, cool and weigh. The loss in weight is reported as moisture.

SILICA.

Silica.

26. Treat 1 g. of the pigment in a covered dish or casserole with 30 cc. of HCl (1:1), heat until decomposed, wash off and remove cover, and evaporate to dryness on the steam-bath. Moisten with concentrated HCl and again evaporate to dryness, add 1 to 2 cc. of concentrated HCl, let stand about 5 minutes, add hot water, filter and wash the insoluble matter with hot water. If great accuracy is desired, evaporate the filtrate to dryness, take up with HCl and water, filter on a second paper, wash, and add the residue to the main insoluble. Ignite the insoluble matter, cool and weigh. Determine SiO_2 by volatilization with H_2SO_4 and HF. Make a qualitative examination of any residue that may remain.

ALUMINA.

Alumina.

27. Render the filtrate from the silica faintly alkaline with NH_4OH, boil a few minutes, filter, wash with hot 2-per-cent NH_4Cl solution, ignite and weigh as $Al_2O_3(+Fe_2O_3)$. For more accurate work, dissolve the $Al(OH)_3$ precipitate in HCl and reprecipitate as above.

SODIUM OXIDE.

Sodium Oxide.

28. Acidify the filtrate from the Al_2O_3 with H_2SO_4, evaporate to dryness, ignite (finally adding solid ammonium carbonate) and weigh as Na_2SO_4. Calculate to Na_2O. If calcium is present it should be precipitated with ammonium oxalate in the filtrate from the Al_2O_3, ignited and weighed as CaO, and the sodium determined in the filtrate from the calcium oxalate, as described.

TOTAL SULFUR

Total Sulfur.

29. Mix 1 g. of the ultramarine with 4 g. of Na_2CO_3 and 4 g. of Na_2O_2 in a nickel crucible, cover with about 1 g. of Na_2CO_3 and fuse, using an aluminum or asbestos shield to prevent the sulfur being taken up from the gas. Dissolve the fused mass in dilute HCl, filter and wash, if necessary (there should be no insoluble residue), precipitate with $BaCl_2$ and determine total sulfur by weighing as $BaSO_4$. Calculate to S.

SULFUR PRESENT AS SULFATE.

30. Dissolve 1 g. of the pigment in dilute HCl, boil to expel H_2S, and filter if necessary; make the solution faintly alkaline, with NH_4OH and just distinctly acid with HCl, and treat with $BaCl_2$ in the usual manner. Calculate $BaSO_4$ to SO_3 and to S. **Sulfur as Sulfate.**

SULFUR PRESENT AS SULFIDE.

31. Subtract the sulfur present as sulfate from the total sulfur. **Sulfur as Sulfide.**

METHODS OF ANALYSIS OF COBALT BLUE.[1]

This pigment is essentially a compound of the oxides of aluminum and cobalt. Certain shades of ultramarine blue are often sold under the name "cobalt blue."

MOISTURE.

32. Heat 2 g. of the pigment at 105° C. for 2 hours. The loss in weight is reported as moisture. **Moisture.**

ALUMINA.

33. Fuse 1 g. of the pigment with 12 to 15 g of sodium or potassium pyrosulfate, cool, digest with water and HCl, filter, and wash the residue with hot water. Make the filtrate up to 250 cc. in a graduated flask and mix. Ignite the residue, cool, weigh, and examine for SiO_2 and $BaSO_4$. Dilute an aliquot portion of the filtrate to 200 cc., add 5 g. of NH_4Cl, heat to boiling, and add dilute NH_4OH till just distinctly alkaline (a few drops of 0.2-per-cent alcoholic solution of methyl red is recommended as indicator). Boil for one or two minutes, filter at once, dissolve the precipitate with HCl, and reprecipitate as before. Filter, wash thoroughly with hot 2-per-cent NH_4Cl (or NH_4NO_3) solution, ignite, and weigh as Al_2O_3. **Alumina.**

CALCIUM AND MAGNESIUM.

34. Unite the filtrates from the Al_2O_3, saturate with hydrogen sulfide, filter, and determine calcium and magnesium in the filtrate in the usual manner. **Calcium and Magnesium.**

COBALT OXIDES.

35. Subtract the determined constituents from 100 and report the difference as cobalt oxides, unless a qualitative examination shows the presence of other substances in significant amounts. Should the pigment contain phosphoric acid (or arsenic acid) in more than negligible amounts, these must be removed before determining aluminum, calcium and magnesium.[2] **Cobalt Oxides.**

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[1] "Analysis of Paint and Varnish Products," C. D. Holley, p. 210 (1912).

[2] See "Technical Methods of Chemical Analysis," Lunge-Keane, Vol. III, Part II, p. 978 (1914).

METHODS OF ANALYSIS OF SUBLIMED BLUE LEAD.[1]

TOTAL LEAD.

Total Lead. 36. Dissolve 1 g. of the sample in 100 cc. of a mixture consisting of 125 cc. of 80-per-cent acetic acid, 95 cc. of NH_4OH (sp. gr. 0.90) and 100 cc. of water. Add the solution while hot and dilute with 50 cc. of water, boil until all is dissolved except carbon. Dilute to 200 cc. and titrate with standard ammonium molybdate solution, using a freshly prepared solution of one part of tannic acid in 300 parts of water as an outside indicator. Run a blank and correct for same. The ammonium molybdate solution contains 8.67 g. per liter and is standardized against pure lead foil, pure PbO, or pure $PbSO_4$.

TOTAL SULFUR.

Total Sulfur. 37. Treat 0.5 g. of the sample in a beaker with 10 cc. of water and a few cc. of bromine water. Boil gently until all the bromine has passed off. Dilute with water, add another portion of bromine water, boil, and continue the treatment until the sediment has become white in color. Add 8 cc. of HNO_3, evaporate the solution until the brown fumes of nitric acid have disappeared, dilute with water and add an excess of Na_2CO_3. Boil gently (covered) for from 10 to 15 minutes and let stand for 4 hours. Dilute with hot water, filter, and wash with hot water. Reject the residue. Acidify the filtrate (about 200 cc.) with HCl and add an excess of about 2 cc. of the acid. Boil and add a slight excess of 10-per-cent barium chloride solution. Let stand on a steam-bath about 1 hour, filter, wash with hot water, ignite, and weigh as $BaSO_4$. Calculate the $BaSO_4$ to S.

LEAD SULFATE.

Lead Sulfate. 38. On a separate sample determine the sulfate directly with Na_2CO_3 as in the preceding paragraph, without any preliminary treatment with bromine water.

LEAD SULFITE.

Lead Sulfite. 39. Boil 1.5 g. of the sample with 3 g. of Na_2CO_3, let stand, filter, and wash thoroughly. To the filtrate add 3 cc. of bromine water, heat gently to oxidize the sulfite to sulfate and precipitate with $BaCl_2$ solution. Filter, wash, ignite, and weigh as $BaSO_4$. Deduct the amount present as sulfate and calculate the remainder to lead sulfite.

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[1] "The Chemical Analysis of Lead and its Compounds," Schaeffer and White, pp. 22 to 24.

LEAD SULFIDE.

40. Deduct the sulfur present as sulfate and sulfite from the total sulfur and report the difference as lead sulfide. **Lead Sulfide.**

LEAD CARBONATE.

41. Determine any CO_2 present by the evolution method, removing any H_2S or SO_2 formed by means of $KMnO_4$ or CrO_3 solution. Calculate to $PbCO_3$. **Lead Carbonate.**

LEAD OXIDE.

42. Deduct the lead present as sulfate, sulfite, sulfide, and carbonate from the total lead and report the difference as lead oxide (PbO). **Lead Oxide.**

ZINC OXIDE.

43. Boil 1 g. of the sample with a solution of 4 g. of NH_4Cl in 30 cc. of water plus 6 cc. of concentrated HCl. Dilute to 200 cc. with hot water, add 2 cc. of a saturated sodium thiosulfate solution, and titrate with a standard solution of potassium ferrocyanide, using a 5-per-cent solution of a uranium nitrate as an outside indicator. Report as ZnO. **Zinc Oxide.**

CARBON AND VOLATILE MATTER.

44. Ignite a weighed portion of the sample in a partially covered crucible at a low red heat for 2 hours, cool, and weigh. Report the loss in weight as carbon and volatile matter. **Carbon and Volatile Matter.**

METHODS OF ANALYSIS OF GREEN PIGMENTS.

(CHROME GREEN)

A pure chrome green should contain only Prussian blue and pure chrome yellow. A microscopic examination should be made to determine whether the green is a combined precipitation product, which is of the greater value, or one mixed after separate precipitation. A good green will show the presence of green and blue particles, while a poor green will show yellow and blue particles mixed with green.

MOISTURE.

45. Heat 2 g. of the pigment at 105° C. for two hours. The loss in weight is reported as moisture. **Moisture.**

INSOLUBLE MATTER.

46. Heat gently 1 g. of the pigment in a small porcelain dish until the blue color has been decomposed. The heating should be carried **Insoluble Matter.**

out very carefully so as not to render the iron difficultly soluble. (With some very pure chrome greens it may be advantageous to mix the sample with 2 to 5 times its weight of pure barium sulfate before igniting.) Let cool, transfer to a beaker, and determine insoluble matter as outlined in Section 5 for Yellow Pigments.

LEAD.

Lead.

47. Determine lead in the filtrate from the above as outlined in Section 6 for Yellow Pigments.

IRON, ALUMINA AND CHROMIUM.

Iron, Alumina, Chromium.

48. Determine iron, aluminum and chromium in the filtrate from the PbS as outlined in Section 7 for Yellow Pigments, making a double precipitation.

ZINC, CALCIUM, AND MAGNESIUM.

Zinc, Calcium, Magnesium.

49. Determine zinc, calcium and magnesium in the filtrate from the iron, aluminum and chromium determination as outlined in Section 8 for Yellow Pigments.

CARBON DIOXIDE.

Carbon Dioxide.

50. Determine carbon dioxide by the evolution method, using dilute HNO_3 (1 : 5).

SULFURIC ANHYDRIDE.

Sulfuric Anhydride.

51. Heat gently 1 g. of the pigment as in Section 46, cool, transfer to a beaker, add 30 cc. of concentrated HCl, cover, and heat on a steam-bath for about 30 minutes (in some cases, the iron compounds will go into solution more readily by letting the solution stand for some time at room temperature and then heating). Wash off cover, add 50 cc. of boiling water, boil for five minutes, filter, render the filtrate faintly alkaline with NH_4OH, then slightly acid with HCl, heat to boiling, and precipitate with $BaCl_2$ (15 cc. of 10-per-cent solution) in the usual manner, boiling about ten minutes. Filter, wash with hot water, ignite, and weigh the $BaSO_4$.

NITROGEN.

Nitrogen.

52. Determine nitrogen on a 1-g. portion of the pigment by the Kjeldahl-Gunning Method, digesting for at least 2½ hours.

WATER-SOLUBLE MATTER.

Water-Soluble Matter.

53. Weigh 2.5 g. of the pigment into a graduated 250-cc. flask, add 100 cc. of water, and boil for five minutes. Dilute with water, let stand until at room temperature, make up to the mark, mix, and let settle. Filter through dry paper and discard the first 25 cc. Transfer 100 cc. of the clear filtrate to a weighed dish, evaporate to dryness on a steam-bath, dry in an oven at 105° C. for 30 minutes, cool and weigh.

ADDED COLORING MATTER AND TINTING STRENGTH.

Coloring Matter.

54. Make the test for added coloring matter and tinting strength in accordance with Section 3. Also test the pigment with dilute acid for the presence of ultramarine blue (evolution of hydrogen sulfide).

TENTATIVE METHOD OF TEST
FOR
MELTING POINT OF PETROLATUM.[1]

Serial Designation: D 127 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1922.

I. DEFINITION.

Definition.

1. *A.S.T.M. Petrolatum Melting Point.*—The temperature at which petrolatum becomes sufficiently fluid to leave the thermometer used in making the determination of melting point.

II. APPARATUS.

Thermometers.

2. (*a*) The melting point thermometer shall conform to the specifications for the A.S.T.M. paraffin wax melting point thermometer, as specified in Section 6 of the Standard Method of Test for Melting Point of Paraffin Wax (Serial Designation: D 87) of the American Society for Testing Materials.[2]

(*b*) The bath thermometer shall be of any suitable type accurate throughout the required range to 2° F.

Test Tubes.

3. The test tubes shall be 25 by 100 mm. in size, and shall be supplied with corks grooved at sides to permit air circulation and bored at the exact center to receive the thermometer.

Beakers.

4. The beakers shall be of the tall form type and have a capacity of 600 cc.

III. PROCEDURE.

Procedure.

5. (*a*) Samples of sufficient size that exactly represent the petrolatum under inspection shall be secured. The material shall be melted slowly in a casserole or other suitable dish with stirring until the temperature reaches 180° F. The source of heat shall then be removed and the petrolatum allowed to cool to 15° F. above th

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

[2] A.S.T.M. Standards Adopted in 1922.

temperature that it is anticipated will be its melting point. The thermometer bulb shall be chilled to 40° F., wiped dry and while still cold thrust into the melted petrolatum so that approximately the lower half is submerged. It shall be withdrawn immediately, held vertically away from the heat until the surface dulls and suspended at a temperature of not over 80° F. for 60 minutes.

(*b*) The thermometer shall be securely fixed in a test tube by means of a cork so that the lowest point is 15. mm. above the bottom of the test tube. The test tube shall be surrounded with a water bath at a temperature of 60° F. The temperature of the bath shall be raised at a rate of 2° F. per minute to 100° F., then at a rate of 1° F. per minute until the first drop of petrolatum leaves the thermometer. The temperature at this instant shall be recorded.

Melting Point.

6. If the variation of three such determinations does not exceed 2° F., the average of these three determinations shall be reported as the melting point of the sample under test. If the variation of three determinations is greater than 2° F., two additional determinations shall be made and the average of five determinations reported as the melting point.

TENTATIVE METHOD OF ANALYSIS OF GREASE.[1]

Serial Designation: D 128 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1922.

Scope.

1. These methods of analysis permit determinations sufficiently accurate for referee purposes of all the constituents of greases likely to be covered by specifications. These constituents are fillers and ash, soap bases, soap, fat, water, excess alkali or acid, petroleum products and unsaponifiable matter. No quantitative determination of glycerin is described, but a procedure is outlined for its qualitative detection.

I. SAMPLE.

Sample.

2. The size of sample for the soap determination (Methods (1) and (2) for Determination of Fillers, Soap, Fat, Petroleum Oil and Unsaponifiable Matter) shall be from about 8 to 30 g., depending on the consistency of the grease, which is chiefly determined by the percentage of soap present. Ten to twenty grams is usually a convenient amount for No. 3 Cup Grease, while thin transmission and other greases require a larger sample. The original sample should be stirred or mixed until uniform.

Accuracy of Weighing.

3. Samples need not be weighed more closely than 0.1 g.

II. SOLVENTS.

Petroleum Ether.

4. The petroleum ether shall have an end point not higher than 200° F., and 125 cc. of it shall not consume more than 0.2 cc. of 0.5 *N* potassium hydroxide when a blank test is made as follows:

One hundred and twenty-five cubic centimeters of petroleum ether shall be boiled with 10 cc. of 0.5 *N* alcoholic potassium hydroxide and 50 cc. of neutral 50-per-cent alcohol for $1\frac{1}{2}$ hours on a hot plate, using a glass tube of about 7 mm. internal diameter and 75 cm. long as a reflux condenser. After cooling, the solutions shall be titrated with 0.5 *N* hydrochloric acid and phenolphthalein. Not less than 9.8 cc. of 0.5 *N* acid shall be required for neutralization. The amount of alkali consumed in this test shall be deducted as a blank correction in the fat determination on solution (*E*).[1]

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Alcohol. 5. The alcohol shall be prepared from commercial 95-per-cent grain or denatured grain alcohol by distilling from sodium hydroxide, diluting to 50 per cent (or 70 per cent) by volume with distilled water and neutralizing exactly with sodium or potassium hydroxide and phenolphthalein.

Phenolphthalein. 6. The phenolphthalein solution shall be prepared by dissolving 1.0 g. of phenolphthalein in 50 cc. of strong redistilled alcohol, adding 50 cc. of water, and neutralizing with sodium or potassium hydroxide.

Hydrochloric Acid. 7. Concentrated c.p. hydrochloric acid shall be used when "concentrated hydrochloric acid" is specified. Hydrochloric acid, 10-per-cent, shall contain 10 per cent by weight of absolute HCl, with a permissible variation of ± 0.5 per cent.

III. PROCEDURE.

(*A*) *Determination of Ash.*

NOTE.—The determination of the total ash should not in general be regarded as of any great importance. It is, however, sometimes required. This determination is often unsatisfactory on account of interaction between sodium carbonate derived from the soap, and inorganic fillers. There is always likelihood of reaction with the porcelain crucible itself on account of the long continued heating necessary to burn out all carbon. Moreover, if much sodium or potassium carbonate is present, the ash is fusible and often encloses carbon, making complete removal of the latter very difficult. Results will always be low in the presence of easily reducible oxides of volatile metals. There is also uncertainty as to when calcium carbonate has been completely ignited to calcium oxide. Ash determinations made on the same sample in different laboratories are likely to vary widely. For these reasons, it is usually preferable to make separate determinations of the percentage of fillers and of soap, from which data a calculation is easily made giving all the information to be gained from a direct determination of total ash.

8. The percentage of ash shall not be included in the total of the analysis.

(*1*) *Rapid Routine Method of Ash Determination.*

9. From 2 to 5 g. of grease shall be placed in a weighed porcelain crucible, and the sample weighed to the nearest 0.1 g. If lead or zinc soap is known to be absent, a platinum crucible is more convenient. The combustible matter shall be burned off slowly and the residue finally ignited until the ash is free of carbonaceous matter. The crucible and contents shall then be cooled in a desiccator and weighed, reporting the result as percentage of ash.

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[1] Solutions designated by capital letters in parentheses refer to the solutions given in Fig. 1.

(2) *Alternative Method of Ash Determination.*

Ash, Alternative.

10. The sample shall be burned as in method (1) until the ash is nearly free from carbon. The crucible and contents shall then be cooled, the soluble portions dissolved in a little water, and a slight excess of dilute sulfuric acid added, running the acid in carefully from a pipette inserted under a small watch glass covering the crucible. The crucible and contents shall then be warmed on the steam bath until effervescence has ceased. The watch glass shall then be rinsed with water into the crucible. The solution when tested with methyl orange for free acidity shall show free acid present. The contents of the crucible shall be evaporated to dryness, and the whole ignited at a low red heat, adding a few small pieces of dry ammonium carbonate to drive off the excess of sulfur trioxide. After cooling and weighing, the result shall be reported as "percentage of ash as sulfates."

The alternative method gives more concordant results than the first method, but requires more time and manipulation.

(*B*) *Qualitative Examination of Ash.*

Detection of Bases.

11. An easily fusible ash, dissolving completely in water to give a strongly alkaline solution, indicates a grease containing sodium, potassium, or both. A white infusible ash, practically insoluble in water, but imparting to it an alkaline reaction, may indicate calcium, with or without magnesium or aluminium. Zinc is shown by the yellow color of the ash while hot, and lead may be indicated by the presence of metallic globules, or by the yellow color of the ash when cold.

12. The ash shall be dissolved in dilute nitric or hydrochloric acid, and the presence of the several bases confirmed by suitable chemical tests, any standard scheme of qualitative analysis being followed.

(*C*) *Quantitative Examination of Ash.*

13. For the quantitative examination of ash any standard analytical procedure shall be used, the choice of methods being based on the information gained from the qualitative tests. If only one base is present, a quantitative determination is in general unnecessary.

(*D*) *Determination of Fillers, Soap, Fat, Petroleum Oil and Unsaponifiable Matter.*

Choice of Method.

14. Cup, fiber and sponge greases, with or without graphite, and all comparatively light colored greases, including axle greases,

shall be examined by method (1). Dark greases containing residuum, asphaltic oils and asphalt, tars, etc., shall be examined by method (2), as these ingredients usually cause stubborn emulsions if a shaking-out process is applied at the start.

(1) *Determination of Filler, Soap, Fat, Etc.*

Determination of Filler.

15. The sample shall be weighed in a small beaker (see Section 2), 75 cc. of petroleum ether and 50 cc. of 10-per-cent hydrochloric acid added and the beaker warmed on the steam bath, stirring until all soap lumps have disappeared and the upper layer is clear. If undissolved mineral matter or other filler is present, both layers shall be filtered through a Gooch crucible provided with a suitable mat, the beaker and crucible washed with water and petroleum ether, and the crucible finally washed with strong alcohol, collecting the alcohol washings separately and discarding them. The crucible and contents shall then be dried at 120° C. and weighed, and the result reported as "percentage of insoluble matter" (graphite, mica, talc, asbestos, gypsum, wood pulp, etc.)

Determination of Gypsum.

16. If gypsum is present as a filler, the results obtained in the determination described in Section 15 will be too low because of the solubility of calcium sulfate in hydrochloric acid. A sample of about 5 g. of grease shall be weighed in a small beaker, and decomposed with 50 cc. of petroleum ether and 25 cc. of concentrated hydrochloric acid, warming on the steam bath until all gypsum is dissolved. The contents of the beaker shall be cooled and poured into a separatory funnel, the beaker rinsed with water and a little petroleum ether and the solutions in the funnel allowed to separate clearly. The lower layer shall then be drawn into a beaker, and the petroleum ether in the separator washed with two portions of 20 cc. each of 10-per-cent hydrochloric acid, adding the washes to the strong acid solution in the separator. The hydrochloric acid solution in the beaker shall then be evaporated on the steam bath almost to dryness, diluted to 150 cc. with water, heated to boiling and treated with 10 cc. of 10-per-cent barium chloride solution. The barium sulfate shall then be filtered off and ignited in the usual way, and from the weight of the barium sulfate, the percentage of calcium sulfate shall be calculated, reporting it as $CaSO_4 \cdot 2H_2O$.

NOTE.—Chalk and other forms of alkaline earth carbonates are not determined by this method, but are considered under the determination of free alkalinity, Section 24.

Determination of Soap.

17. The combined filtrate and washes from the determination of fillers (Section 15), except the alcohol, which is discarded, shall be

placed in a separator, allowed to clear, and the aqueous layer (*A*),[1] which contains all the bases as well as glycerin, shall be drawn into another separator. The petroleum ether layer (*B*) shall be washed three times with 25 cc. of water to remove hydrochloric acid, adding

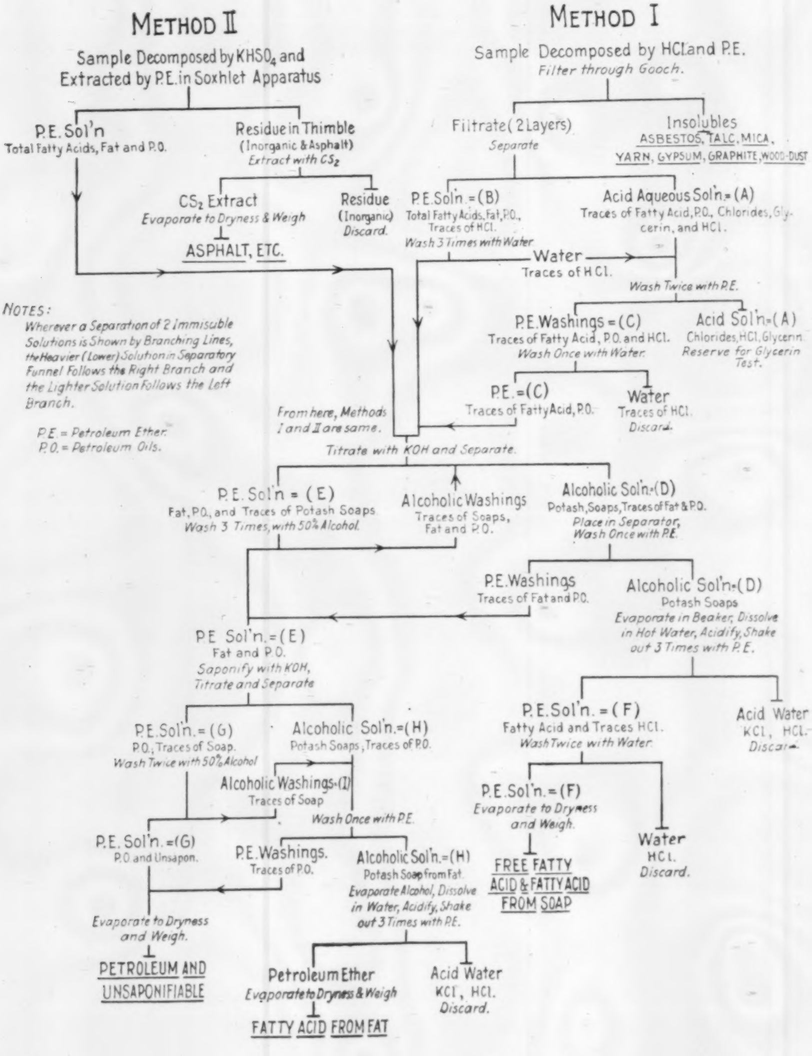
METHOD II
Sample Decomposed by KHSO$_4$ and Extracted by P.E. in Soxhlet Apparatus
P.E. Sol'n
Total Fatty Acids, Fat and P.O.
Residue in Thimble
(Inorganic & Asphalt)
Extract with CS$_2$
CS$_2$ Extract
Evaporate to Dryness & Weigh
ASPHALT, ETC.
Residue
(Inorganic)
Discard.
METHOD I
Sample Decomposed by HCl and P.E.
Filter through Gooch.
Filtrate (2 Layers)
Separate
Insolubles
ASBESTOS, TALC, MICA, YARN, GYPSUM, GRAPHITE, WOOD-DUST
P.E. Sol'n. = (B)
Total Fatty Acids, Fat, P.O., Traces of HCl.
Wash 3 Times with Water
Acid Aqueous Sol'n. = (A)
Traces of Fatty Acid, P.O., Chlorides, Glycerin, and HCl.
Water
Traces of HCl.
Wash Twice with P.E.
P.E. Washings = (C)
Traces of Fatty Acid, P.O. and HCl.
Wash Once with Water.
Acid Sol'n. = (A)
Chlorides, HCl, Glycerin.
Reserve for Glycerin Test.
P.E. = (C)
Traces of Fatty Acid, P.O.
Water
Traces of HCl.
Discard.
NOTES:
Wherever a Separation of 2 Immiscible Solutions is Shown by Branching Lines, the Heavier (Lower) Solution in Separatory Funnel Follows the Right Branch and the Lighter Solution Follows the Left Branch.
P.E. = Petroleum Ether.
P.O. = Petroleum Oils.
From here, Methods I and II are same.
Titrate with KOH and Separate.
P.E. Sol'n = (E)
Fat, P.O., and Traces of Potash Soaps
Wash 3 Times, with 50% Alcohol.
Alcoholic Washings
Traces of Soaps, Fat and P.O.
Alcoholic Sol'n. = (D)
Potash, Soaps, Traces of Fat & P.O.
Place in Separator, Wash Once with P.E.
P.E. Washings
Traces of Fat and P.O.
Alcoholic Sol'n. = (D)
Potash Soaps
Evaporate in Beaker, Dissolve in Hot Water, Acidify, Shake out 3 Times with P.E.
P.E. Sol'n. = (E)
Fat and P.O.
Saponify with KOH, Titrate and Separate
P.E. Sol'n. = (G)
P.O., Traces of Soap.
Wash Twice with 50% Alcohol
Alcoholic Sol'n. = (H)
Potash Soaps, Traces of P.O.
Alcoholic Washings = (I)
Traces of Soap
Wash Once with P.E.
P.E. Sol'n. = (G)
P.O. and Unsapon.
P.E. Washings.
Traces of P.O.
Alcoholic Sol'n. = (H)
Potash Soap from Fat.
Evaporate Alcohol, Dissolve in Water, Acidify, Shake out 3 Times with P.E.
Evaporate to Dryness and Weigh.
PETROLEUM AND UNSAPONIFIABLE
Petroleum Ether
Evaporate to Dryness & Weigh
FATTY ACID FROM FAT
Acid Water
KCl, HCl.
Discard.
P.E. Sol'n. = (F)
Fatty Acid and Traces HCl.
Wash Twice with Water.
Acid Water
KCl, HCl.
Discard.
P.E. Sol'n. = (F)
Evaporate to Dryness and Weigh.
FREE FATTY ACID & FATTY ACID FROM SOAP
Water
HCl.
Discard.

FIG. 1.—Scheme of Grease Analysis.

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[1] Solutions designated by capital letters in parentheses refer to the solutions given in Fig. 1.

the washings to (*A*). Solution (*B*) shall then be run into a 250-cc. separator. The aqueous solution (*A*) shall then be washed twice with 20 cc. of petroleum ether (*C*), whereupon (*A*) is set aside for examination for glycerin (see Section 18). Solution (*C*) shall then be washed once with 15 cc. of water, which is rejected, and (*C*) shall be added to (*B*). If (*B*) and (*C*) are comparatively light colored, an approximate determination of free fatty acids and fatty acids from soap may now be made by titrating the solution in the separator with 0.5 *N* alcoholic potassium hydroxide and phenolphthalein, using 200 as the average neutralization value of the fatty acid (that is, 1.0 g. of fatty acid requires 200 mg. of absolute KOH for neutralization). If solutions (*B*) and (*C*) are dark, a few drops of phenolphthalein and sufficient 0.5 *N* alcoholic potassium hydroxide shall be added to make the alcoholic layer distinctly alkaline after vigorous shaking. If the solutions have been titrated, a slight excess of alkali shall be added before separating. The conservative addition of strong alcohol at this point may aid in securing rapid and sharp separation. The two solutions shall be allowed to separate sharply, and the lower alcoholic layer (*D*) drawn off into another separator. The upper petroleum ether layer (*E*) shall be washed three times, with 30, 25 and 20 cc. of neutral 50-per-cent alcohol respectively, adding these washes to (*D*). Solution (*D*) shall be washed with 25 cc. of petroleum ether, after which (*D*) is drawn off into a beaker, and the petroleum ether added to (*E*). Solution (*D*) shall then be evaporated to a small volume to remove alcohol, the residue of potassium soap washed into a separator with hot water, acidified with hydrochloric acid and shaken out three times, with 50, 30 and 20 cc. of petroleum ether (*F*), respectively. Solution (*F*) shall be run into another separator and washed twice with 20-cc. portions of water, which is discarded. Solution (*F*) shall then be transferred to a weighed beaker and evaporated to dryness on the steam bath, blowing with air to remove all traces of petroleum ether. The residue consisting of free fatty acid and fatty acid from soap shall be heated one hour at 120° C. and weighed. The exact neutralization value shall then be determined on as large a sample of these fatty acids as possible. From the total fatty acid found here, the free acid if any (see sections 23 and 25) shall be deducted and the remainder calculated to percentage of soap, using the ash analysis as a guide in distributing the bases, if more than one are present.

The fatty acids may be identified to some extent by special tests, such as odor, crystal form, melting point, iodine number, neutralization value, color reactions, etc.

Detection of Glycerin.

18. In case it is desired to determine whether a grease has been made from whole fats or from fatty acids, solution (*A*) shall be neutralized with dry sodium carbonate and sufficient excess added to precipitate calcium or other metals. The whole mass shall then be evaporated to dryness, the residue extracted several times with strong alcohol, the combined alcoholic extracts filtered, and the alcohol evaporated. The residue will then contain most of the glycerin, with a little sodium chloride. The presence or absence of glycerin in the residue shall be confirmed by suitable qualitative tests.

Since fats on saponification yield between 10 and 11 per cent of glycerin, and this analytical scheme does not include a quantitative determination of glycerin, the total percentages in greases made from fats should always be less than 100.

Determination of Fat.

19. The petroleum ether solution (*E*) (Section 17), containing free fat, petroleum oils, and unsaponifiable matter shall be concentrated to a volume of about 125 cc. in a 300-cc. Erlenmeyer flask, 10 cc. of 0.5 *N* alcoholic potassium hydroxide and 50 cc. of strong neutral alcohol added, and the whole boiled on a hot plate with an air condenser for $1\frac{1}{2}$ hours. The uncombined alkali shall be titrated with 0.5 *N* hydrochloric acid, and from the alkali consumed, corrected for the blank determination as specified in Section 4, the percentage of free fat shall be calculated, using 195 as the average saponification value (that is, 1.0 g. of fat requires 195 mg. of absolute KOH for saponification.)

The titrated solution (*G*) shall be placed in a separator, the alcoholic lower layer (*H*) drawn off into another separator and the remaining traces of soap removed as described for (*B*) and (*C*), Section 17, making only two washes with 30 and 20 cc. of 50-per-cent alcohol (*I*). Solutions (*H*) and (*I*) shall be combined, washed once with a little petroleum ether, which is added to solution (*G*), and solutions (*H*) and (*I*) then evaporated to a small volume and the fatty acid isolated as described for (*D*), Section 17. The percentage of fat may be checked by weighing and titrating the free fatty acid.

Determination of Petroleum Oil.

20. The petroleum ether solution (*G*), now containing all the hydrocarbon oils and unsaponifiable matter shall be evaporated to dryness in a weighed beaker as described for (*F*), Section 17, the residue weighed, and the result reported as "petroleum oils plus unsaponifiable matter."

An approximate determination of the viscosity of the petroleum oil may be made by using a 2 or 5-cc. pipette, which has been standardized against oils of known viscosities. If a complete characterization of the petroleum products is required, a new sample of from 150 to

200 g. of grease shall be decomposed as described above, except that all quantitative operations shall be omitted, as well as the isolation of the free fatty acids, and the use of standard alkali and acid is not necessary.

If the grease contains rosin oil, beeswax, de gras, spermaceti, spermatin, montan wax, candle pitch, and other materials containing a large amount of unsaponifiable substances, the petroleum oils isolated from solution (*G*) will contain the unsaponifiable matter, and the constants found will differ from those of the petroleum products used in making the grease. In most cases, no further separation is possible except in the hands of skillful and experienced operators who can devise special methods to suit the individual conditions.

(*2*) *Determination of Filler, Soap, Fat, Etc.*

Method for Dark Greases.

21. The sample shall be weighed in a 3-in. porcelain dish, 10 g. of granulated acid potassium sulfate added and 10 g. of clean dry ignited sand. The dish and contents shall be heated on the steam bath with frequent stirring until all water is driven off, two hours usually being sufficient. After cooling and breaking up lumps with a small pestle, the mixture shall be transferred quantitatively to an extraction thimble, using a little petroleum ether to wash the last traces into the thimble, which should be already placed in a Soxhlet apparatus. The thimble shall be extracted thoroughly with petroleum ether, the extract concentrated somewhat if necessary, and the free fatty acid and fatty acid from soap titrated with 0.5 *N* alcoholic potassium hydroxide as in solutions (*B*) and (*C*), in method (1), Section 17. From this point on, the procedure is identical with that given in method (1), Sections 17, 19 and 20.

Determination of Asphalt and Tarry Matter.

22. The thimble shall be extracted a second time with carbon disulfide, the extract evaporated to dryness, heated for one hour to 120° C. and weighed, the results being reported as asphaltic and tarry matter. The residue in the thimble shall be discarded.

(*E*) *Determination of Free Alkali and Free Acid.*

Free Alkali.

23. From 10 to 30 g. of grease shall be weighed in a small beaker, dissolved as completely as possible in 75 cc. of petroleum ether by stirring with a spatula, the mixture washed into a 250-cc. Erlenmeyer flask with a small amount of petroleum ether, and the beaker rinsed with 50 cc. of 70-per-cent alcohol, the alcohol being poured into the flask, after which a few drops of phenolphthalein solution shall be added and the whole shaken vigorously. If the alcoholic layer, after

settling for a few seconds, is pink, 10 cc. of 0.5 *N* hydrochloric acid shall be added, the solutions boiled on a hot plate for ten minutes to expel carbon dioxide, and the excess acid titrated back with 0.5 *N* alcoholic potassium hydroxide. The free alkalinity shall be calculated in terms of hydroxide of the predominating base.

Insoluble Carbonates.

24. If chalk or any other form of alkaline earth carbonate, or lead carbonate, is present as a filler, it will be detected by effervescence on adding the hydrochloric acid. As the amount of such carbonates is likely to be considerable, the volume of 0.5 *N* hydrochloric acid added shall be increased sufficiently to dissolve all carbonate and leave a slight excess of acid. The solution shall be boiled for two minutes and the excess acid titrated back with 0.5 *N* alcoholic potassium hydroxide, and from the acid consumed, its equivalent in calcium carbonate, etc., shall be calculated, disregarding any other forms of alkalinity which may have been present.

Free Acid.

25. If the original alcoholic layer is not pink, the solution shall be titrated carefully in the cold with 0.5 *N* alcoholic potassium hydroxide, shaking well after each addition. The acidity shall be calculated as oleic acid.

26. If soaps of iron, zinc, aluminium, or other weak bases are present, a determination of free acid is not possible, since these metallic soaps react with potassium hydroxide. Up to the present, no means has been devised whereby this determination can be made directly.

(*F*) *Determination of Water.*

Water.

27. The quantity of water shall be determined in accordance with the Tentative Method of Test for Water in Petroleum Products (Serial Designation: D 95 - 21 T) of the American Society for Testing Materials.[1]

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 666 (1921).

TENTATIVE METHOD OF TEST
FOR
SULFUR IN PETROLEUM OILS HEAVIER THAN ILLUMINATING OIL.[1]

Serial Designation: D 129 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. APPARATUS.

Oxygen Bomb.

1. The oxygen bomb shall have a capacity of not less than 300 cc., and shall be of a design or construction such that no leaks shall occur at any pressure or temperature generated during the test and such that when open, liquid contents can be easily and completely drained. The inner surfaces shall be of materials that are chemically and physically resistant to the process or products of combustion. The gaskets, insulating materials, etc., shall be, as far as possible, physically and chemically resistant and in no event shall they undergo any reaction which would increase or decrease the sulfur content of the bomb liquors.

Oil Cup.

2. The oil cup shall be of platinum, glazed silica, or other suitable material, with a capacity of not less than 2.5 cc. nor more than 5.0 cc.

Fuse Wire.

3. If a platinum oil cup is used, the fuse wire shall be of platinum; if a glazed silica oil cup is used, the fuse wire may be of either platinum or iron. No. 35 B. & S. gage is a convenient size.

Reagents.

4. (*a*) The distilled water and all reagents should be sulfur free, but in such cases where it is necessary to employ reagents not sulfur free, blanks shall be run and the figures thus obtained used to correct the results of actual determinations.

(*b*) The barium chloride solution shall contain 100 g. of $BaCL_2 \cdot 2H_2O$ per liter.

II. PROCEDURE.

Procedure.

5. (*a*) Twenty cubic centimeters of distilled water shall be placed in the bottom of the bomb. From 0.6 to 0.8 g. of the oil to be tested

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

shall be placed in the weighed oil cup and the weight of this charge shall be determined to an accuracy of at least ±0.002 g. The cup shall be placed in the proper position in the bomb, the ignition mechanism arranged and the bomb closed. Oxygen shall be admitted slowly until a pressure is reached as indicated by the following table:

CAPACITY OF BOMB, CC.	MINIMUM GAGE PRESSURE, ATMOSPHERES.
300 to 350	40
350 to 400	35
400 to 450	30
450 to 500	27.5
Above 500	25

The leads from the firing circuit shall be attached, the bomb placed in a bucket of cold water, and ignited. The bomb shall be allowed to stand in the water for 10 minutes and shall then be removed. The valve of the bomb shall be opened, allowing the gas to escape at an approximately even rate so that the pressure is reduced to atmospheric in not less than 1 minute. The bomb shall be opened, and all parts of its interior, including the oil cup, rinsed with a fine jet of distilled water. All washings, which should not amount to more than 350 cc., shall be collected in a beaker. Particular care should be taken not to lose, by splashing, or otherwise, any of the liquid contents of the bomb. The washings shall be filtered through a washed "qualitative" filter paper. The filter shall be washed thoroughly. Two cubic centimeters of concentrated HCl and 10 cc. of saturated bromine water shall be added to the filtrate. The solution shall be evaporated to about 75 cc. on a steam bath or hot plate. Ten cubic centimeters of hot barium chloride solution shall be added in a fine stream or drop-wise to the hot solution, stirring during the addition and for two minutes afterward. The solution shall be allowed to stand over night, or shall be kept hot for one hour on the steam bath or hot plate, allowing the precipitate to settle for another hour, while cooling. The supernatant liquid shall be filtered through an "ashless quantitative" filter paper, the precipitate washed with water, first by decantation, then on the filter, till free from chloride. The paper and precipitate shall be transferred to a suitable weighed crucible, dried at low heat till moisture is evaporated, the paper charred (without flaming), and finally ignited at a good red heat till the precipitate is just burned white. A satisfactory means of accomplishing these operations is to place the crucible containing the wet filter paper in a cold electric muffle furnace and to turn on the current. Drying, charring, and ignition will usually occur at the desired rate.

(*b*) After ignition is complete, the crucible shall be allowed to cool to room temperature, and weighed. The use of a desiccator is not recommended.

(*c*) From the increase in weight of the crucible the percentage of sulfur shall be calculated from the formula:

$$\text{Percentage of sulfur} = \frac{\text{grams of } BaSO_4 \times 13.734}{\text{grams of oil used.}}$$

Accuracy. 6. Duplicate determinations should agree to ±2 per cent on the basis of the sulfur found.

TENTATIVE METHOD OF TEST

FOR

DETECTION OF FREE SULFUR AND CORROSIVE SULFUR COMPOUNDS IN GASOLINE.[1]

Serial Designation: D 130 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope.

1. This method of test shall be used for the detection of free sulfur and corrosive sulfur compounds in gasoline.

Procedure.

2. A clean strip of mechanically polished pure sheet copper about ½ in. in width and 3 in. in length shall be placed in a suitable clean tube or sample bottle. Gasoline under test shall be added so that the copper strip is completely immersed. The test tube or sample bottle shall be closed with a loosely fitting cork and held in a suitable bath at 122° F. (50° C.).

At the end of three hours the gasoline exposed strip shall be removed and shall be compared with a similar strip of freshly polished copper.

Detection of Sulfur.

3. The presence of sulfur or corrosive sulfur compounds is indicated by the corrosion or discoloration of the gasoline exposed strip when compared with the fresh copper strip.

4. (*a*) Gasoline shall be reported as passing the test when on examination the exposed strip shows no discoloration as compared with the fresh copper strip.

(*b*) Gasoline shall be reported as not passing the test when on examination the exposed strip shows discoloration as compared with the fresh copper strip.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

TENTATIVE METHOD OF TEST
FOR
CLOUD AND POUR POINTS OF PETROLEUM PRODUCTS.[1]

Serial Designation: D 97 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Cloud Point. 1. (*a*) The Cloud Point of a petroleum oil is that temperature at which paraffin wax or other solid substances begin to crystallize out or separate from solution when the oil is chilled under certain definite specified conditions.

Pour Point. (*b*) The Pour Point of a petroleum oil is the lowest temperature at which this oil will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Scope. 2. (*a*) The test for cloud point shall be used only for oils which are transparent in layers $1\frac{1}{2}$ in. thick.

(*b*) The test for pour point shall be used for all other petroleum oils and may be used for oils on which the test for cloud point is permitted.

I. APPARATUS.

(See Fig. 1.)

Test Jar. 3. The test jar, *a*, shall be of clear glass, cylindrical form. flat bottom, approximately $1\frac{1}{4}$ in. in inside diameter and $4\frac{1}{2}$ to 5 in. high. An ordinary 4-oz. oil sample bottle may be used if the test jar is not available.

Thermometer. 4. The thermometer, *b*, shall conform to the following specifications.

Type: Etched stem glass.
Total length: 222 mm.
Stem: Plain front, enamel back, suitable thermometer tubing; diameter 7 to 8 mm.
Bulb: Corning Normal. Jena 16 III, or equally suitable thermometric glass; maximum length, 9.5 mm.; diameter, not greater than stem.
Actuating liquid: Mercury.
Range: −36° to +120° F.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Immersion: 4½ in. The words "4½-in. immersion" etched on the stem and also a line around the stem to indicate the depth of immersion.
Distance to −36° line from bottom of bulb: 120 to 130 mm.
Distance to 120° line from top of stem: 19 to 25 mm.
Expansion chamber: To hold 212° F.
Filled: Nitrogen gas.
Top finish: Plain.
Graduation: All lines, figures and letters clear cut and distinct.
Scale graduated in 2° F. divisions.
Scale numbered every 20° F. starting at −20° F., the −30° line and each succeeding 10° line to be longer than the others.
Special markings: "A.S.T.M. Cloud and Pour," serial number and manufacturer's name or trade mark etched on the stem.
Accuracy: Error at any point on scale shall not exceed one smallest scale division.
Points to be tested for certification: −28°, +32°, +92° F.

Cork. 5. The cork, *c*, shall fit the test jar, and shall be bored centrally to take the test thermometer.

Jacket. 6. The jacket, *d*, shall be of glass or metal, shall be water tight, of cylindrical form, flat bottom, about 4½ in. deep, with inside diameter ½ in. greater than outside diameter of the test jar.

Cork Disk. 7. A disk of cork or felt, *e*, ¼ in. thick and of the same diameter as the inside of the jacket will be required.

Gasket. 8. The ring gasket, *f*, shall be about $\frac{3}{16}$ in. thick, and made to fit snugly around the outside of the test jar and loosely inside the jacket. This gasket may be made of cork, felt or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

Bath. 9. The cooling bath, *g*, shall be of a type suitable for obtaining the required temperatures. The size and shape of the bath are optional but a support, suitable for holding the jacket firmly in a vertical position, is essential. The required bath temperatures may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

NOTE.—The freezing mixtures commonly used are as follows:

For temperatures down to 35° F., ice and water.
" " " " −5° F., crushed ice and sodium chloride.
" " " " −25° F., crushed ice and calcium chloride.
" " " " −70° F., solid carbon dioxide and acetone.

The last named mixture may be made as follows: In a covered metal beaker chill a suitable amount of acetone to 10° F., or lower, by means of an ice-salt mixture. Invert a cylinder of liquid carbon dioxide and draw off carefully into a chamois skin bag the desired amount of carbon dioxide, which through rapid evaporation will quickly become solid. Then add to the chilled acetone enough of the solid carbon dioxide to give the desired temperature.

II. PROCEDURE.

Procedure for Cloud Point.

10. The oil to be tested shall be brought to a temperature at least 25° F. above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the oil is perfectly clear, but such filtration shall be made at a temperature at least 25° F. above the approximate cloud point.

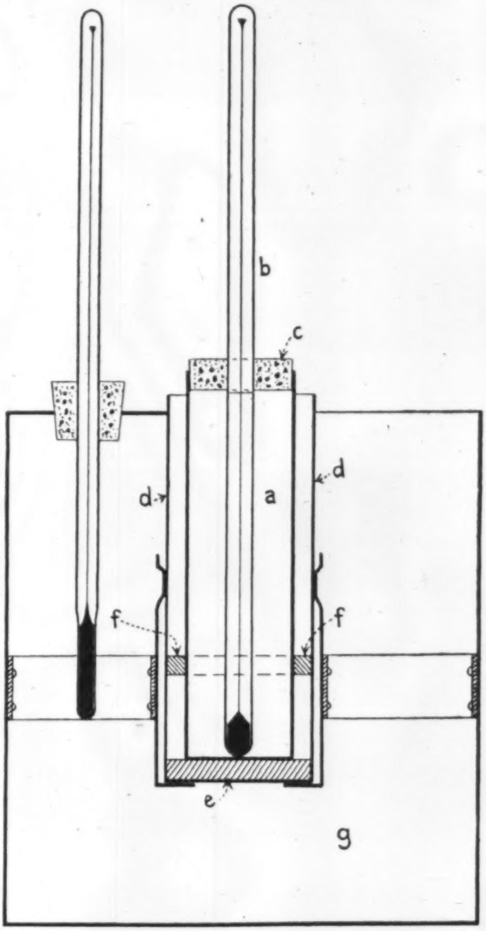

FIG. 1.—Apparatus for Cloud and Pour Test (as assembled for Cloud Test).

The clear oil shall be poured into the test jar, *a*, to a height of not less than 1 nor more than $1\frac{1}{4}$ in. The test jar may be marked to indicate the proper level.

The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb resting on the bottom of the jar.

The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar with the ring gasket, *f*, 1 in. above the bottom shall be inserted into the jacket. The disk, jacket and inside of jacket shall be clean and dry.

The temperature of the cooling bath, *g*, shall be adjusted so that it is below the cloud point of the oil by not less than 15 nor more than 30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

At each test thermometer reading which is a multiple of 2° F., the test jar shall be removed from the jacket, quickly but without disturbing the oil, inspected for cloud, and replaced in the jacket. This complete operation shall require not more than three seconds.

When such inspection first reveals a distinct cloudiness or haze in the oil at the bottom of the test jar, the reading of the test thermometer, corrected for error if necessary, shall be recorded as the cloud point.

Procedure for Pour Point.

11. The oil to be tested shall be brought to a temperature of 90° F., or to a temperature 15° F. higher than its pour point if this pour point is above 75° F. The oil shall then be poured into the test jar, *a*, to a height of not less than 2 nor more than 2¼ in.[1] The jar may be marked to indicate the proper level.

The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the oil.

The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar, with the ring gasket, *f*, 1 in. above the bottom, shall be inserted into the jacket. The disk, gasket and inside of jacket shall be clean and dry.

After the oil has cooled enough to allow the formation of paraffin wax crystals, great care shall be taken not to disturb the mass of the oil nor to permit the thermometer to shift in the oil. Any disturbance of the spongy network of wax crystals will lead to low and fictitious results.

The temperature of the cooling bath, *g*, shall be adjusted so that it is below the pour point of the oil by not less than 15 nor more than

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[1] Test jar and contents shall be immediately placed in the previously assembled apparatus.

30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

At each test thermometer reading which is a multiple of 5° F., the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether the oil around the thermometer remains liquid. As long as the oil around the thermometer flows when the jar is tilted slightly, the test jar shall be replaced in the jacket. The complete operation of removal and replacement shall require not more than three seconds. As soon as the oil around the thermometer does not flow when the jar is tilted slightly, the test jar shall be held in a horizontal position for exactly five seconds and observed carefully. If the oil around the thermometer shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure shall be repeated at the next temperature reading 5° F. lower. In determining the pour point of oils it shall be noted that the first movement of the oil in certain cases is not around the thermometer but from the sides of the test jar. In such cases, this movement shall be considered in making the test. As soon as a temperature is reached at which the oil around the thermometer shows no movement when the test jar is held in a horizontal position for exactly five seconds, the test shall be stopped.

The lowest reading of the test thermometer, corrected for error if necessary, at which the oil around the thermometer shows any movement when the test jar is held in a horizontal position for exactly five seconds shall be recorded as the pour point. It shall be noted that the pour point is the temperature 5° F. above the solid point or temperature at which the test is discontinued.

TENTATIVE SPECIFICATIONS
FOR
BLOCK FOR RECUT GRANITE BLOCK PAVEMENTS.[1]

Serial Designation: D 131 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

General. 1. The blocks shall be of granite of medium-size grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams or disintegrated materials.

I. PHYSICAL PROPERTIES AND TESTS.

Physical Properties. 2. The average of three tests on sample blocks shall conform to the following requirements as to physical properties:

Percentage of wear	not more than 5
(French coefficient of wear	not less than 8)
Toughness	not less than 7

Methods of Testing. 3. (*a*) The percentage of wear and the French coefficient of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Road Material (Serial Designation: D 2) of the American Society for Testing Materials.[2]

(*b*) The toughness shall be determined in accordance with the Standard Method of Test for Toughness of Rock (Serial Designation: D 3) of the American Society for Testing Materials.[2]

II. DIMENSIONS.

Dimensions. 4. The blocks shall conform to the following requirements as to dimensions:

Length on top, in.	6 to 12
Width on top, in.	3½ to 4½
Depth, in.	4¼ to 5¼

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

III. DRESSING.

5. (*a*) The blocks shall be so dressed that the faces will be approximately rectangular in shape, and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding $\frac{1}{2}$ in. in width at the top, and for 1 in. downward therefrom, and not exceeding 1 in. in width at any other part of the joint. **Dressing.**

(*b*) The wearing surface of the blocks shall show no depressions more than $\frac{3}{8}$ in. in depth, and the edges and corners shall be unchipped and unbroken.

IV. INSPECTION.

6. (*a*) At least eight blocks shall be selected for physical tests by the engineer or his authorized representative, subsequent to delivery at the place of use, so as to fairly represent actual deliveries. No sample shall include blocks that would be rejected by a visual examination. The bedding plane shall be marked on at least two of the blocks selected. **Inspection.**

(*b*) All deliveries shall be subjected to further inspection at the place of use, prior to and during laying. All blocks which fail to conform to the requirements of Sections 1, 4 and 5 shall be rejected.

TENTATIVE SPECIFICATIONS
FOR
BLOCK FOR DURAX GRANITE PAVEMENTS.[1]

Serial Designation: D 132 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

General. 1. The blocks shall be of granite of medium-size grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams or disintegrated materials.

I. PHYSICAL PROPERTIES AND TESTS.

Physical Properties. 2. The average of three tests on sample blocks shall conform to the following requirements as to physical properties:

Percentage of wear	not more than 5
(French coefficient of wear	not less than 8)
Toughness	not less than 7

Methods of Testing. 3. (*a*) The percentage of wear and the French coefficient of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Road Material (Serial Designation: D 2) of the American Society for Testing Materials.[2]

(*b*) The toughness shall be determined in accordance with the Standard Method of Test for Toughness of Rock (Serial Designation: D 3) of the American Society for Testing Materials.[2]

II. DIMENSIONS.

Dimensions. 4. The blocks shall be not less than 3 in. nor more than 4 in. in length, width or depth.

III. DRESSING.

Dressing. 5. (*a*) The blocks shall be so dressed that the faces will be approximately rectangular in shape, and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding $\frac{1}{2}$ in. in width at the top, and for 1 in. downward therefrom, and not exceeding 1 in. in width at any other part of the joint.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

(*b*) The wearing surface of the blocks shall show no depressions more than $\frac{3}{8}$ in. in depth, and the edges and corners shall be unchipped and unbroken.

IV. INSPECTION.

6. (*a*) At least 25 blocks shall be selected for physical tests by the engineer or his authorized representative, subsequent to delivery at the place of use, so as to fairly represent actual deliveries. No sample shall include blocks that would be rejected by a visual examination. The bedding plane shall be marked on at least two of the blocks selected. **Inspection.**

(*b*) All deliveries shall be subjected to further inspection at the place of use, prior to and during laying. All blocks which fail to conform to the requirements of Sections 1, 4 and 5 shall be rejected.

TENTATIVE SPECIFICATIONS
FOR
CALCIUM CHLORIDE FOR DUST PREVENTION.[1]

Serial Designation: D 98 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Material Covered. 1. These specifications cover calcium chloride to be applied to the surface of highways as a dust preventive.

I. PROPERTIES AND TESTS.

Physical Properties. 2. The calcium chloride shall be in the form of loose dry lumps or flakes, and fine enough to feed readily through the common forms of spreaders used in road work, and when tested by means of laboratory screens and sieves shall meet the following requirements:

Passing ⅜-in. screen	100	per cent
Retained on ¼-in. screen	not more than 20	"
Passing 20-mesh sieve	not more than 10	"

Chemical Composition. 3. Ten grams of the material dissolved in 100 cc. of boiling water shall show less than 1.0 per cent insoluble residue. Not more than 1.0 cc. of normal acid shall be required to neutralize the alkalinity of the filtrate, using methyl orange. The chemical composition shall conform to the following requirements:

$CaCl_2$ (anhydrous)	not less than 73.	per cent
$MgCL_2$	not more than 0.5	"
NaCl	not more than 2.0	"
Other impurities	not more than 1.0	"

The percentage of calcium chloride shall be calculated from the percentage of calcium in the filtrate above referred to, after making a deduction for the SO_4, which shall be assumed to be in combination as $CaSO_4$.

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[1] **Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.**

II. PACKAGES.

Packages. 4. The calcium chloride shall be delivered in air-tight moisture-proof bags or sacks containing approximately 100 lb. each, or in air-tight steel drums weighing not more than 350 lb. each. The name of the manufacturer, the lot number, the approximate net weight, and the percentages of calcium chloride guaranteed by the manufacturer shall be plainly marked on each container.

III. INSPECTION.

Inspection. 5. Every facility shall be provided the purchaser should he elect to have his own representative sample the material at the plant. If the purchaser decides to sample the material after delivery in the field it is understood that a 3-per-cent variation in content of $CaCl_2$ from the chemical composition stated in Section 3 shall be permissible.

Rejection. 6. Calcium chloride shall be rejected if it fails to pass any of the requirements of these specifications and if it has become caked or sticky in the containers before opening.

IV. BASIS OF PAYMENT.

Basis of Payment. 7. Payment will be made on the basis of total number of pounds of 100-per-cent calcium chloride delivered.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 10 TO 15 PENETRATION, FOR THE MANUFACTURE OF ASPHALT BLOCK.[1]

Serial Designation: D 133 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec. . . . . . . 10 to 15

(*b*) Flash Point (open cup) . . . . . not less than 200° C. (392° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr. . . . . not more than 1 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating . . . . not less than 50 per cent

(*e*) Ductility at 25° C. (77° F.) . . . . 5 cm. to 15 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride. . . . . not less than 99 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by means of Open Cup (Serial Designation: D 92 - 21 T).[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T).[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Method Contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 15 TO 25 PENETRATION, FOR THE MANUFACTURE OF ASPHALT BLOCK.[1]

Serial Designation: D 134 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec.........15 to 25

(*b*) Flash Point (Open Cup)......not less than 200° C. (392° F.)

(*c*) Loss on Heating at 163° C. (325° F.), 50 g., 5 hr...not more than 1 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating....................not less than 50 per cent

(*e*) Ductility at 25° C. (77° F.)................5 cm. to 20 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride ....not less than 99 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 21 T).[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T).[4]

(*e*) *Bitumen Soluble in Carbon Tetrachloride:* Method contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 40 TO 50 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC CONCRETE PAVEMENTS.[1]

Serial Designation: D 99 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec........40 to 50

(*b*) Flash point (open cup).......not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.....
not more than 2 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating...........not less than 60 per cent.

(*e*) Ductility at 25° C. (77° F.)............not less than 30 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride
not less than 99 per cent.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 21 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Method contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] **Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.**

[2] **1921 Book of A.S.T.M. Standards.** [3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] **See p.** 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 50 TO 60 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC CONCRETE PAVEMENTS.[1]

Serial Designation: D 100 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Properties. 1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec......50 to 60

(*b*) Flash point (open cup)........not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr...... not more than 2 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating,..................not less than 60 per cent

(*e*) Ductility at 25° C. (77° F.).............not less than 30 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride not less than 99 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 21 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Method contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] **Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.**

[2] **1921 Book of A.S.T.M. Standards.** [3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] **See** p. 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 60 TO 70 PENETRATION, FOR USE IN SHEET ASPHALT, ASPHALTIC CONCRETE, AND ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 101 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec.......60 to 70

(*b*) Flash point (open cup)........not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.. not more than 2 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..................not less than 60 per cent

(*e*) Ductility at 25° C. (77° F.).............not less than 30 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride not less than 99 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 21 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Method contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 70 TO 90 PENETRATION, FOR USE IN ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 102 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F), 100 g., 5 sec........70 to 90

(*b*) Flash point (open cup).......not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr...
not more than 2 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating....................not less than 60 per cent

(*e*) Ductility at 25° C. (77° F.).............not less than 30 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride
not less than 99 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 – 21 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Method contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 90 TO 120 PENETRATION, FOR USE IN ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 103 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Properties. 1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec......90 to 120

(*b*) Flash point (open-cup)........not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr...... not more than 2 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..................not less than 60 per cent

(*e*) Ductility at 25° C. (77° F.).............not less than 30 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride not less than 99 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 – 21 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Method contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 120 TO 150 PENETRATION, FOR USE IN ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 135 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec.......120 to150

(*b*) Flash point (open cup)......not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.......... not more than 2 per cent

(*d*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating....................not less than 60 per cent

(*e*) Ductility at 25° C. (77° F.)............not less than 30 cm.

(*f*) Proportion of bitumen soluble in carbon tetrachloride not less than 99 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*e*):

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 21 T).[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T.).[4]

(*e*) ***Proportion of Bitumen Soluble in Carbon Tetrachloride:*** Method contained in *Bulletin No. 314*, U. S. Department of Agriculture.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards. [3] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[4] See p. 807.

TENTATIVE SPECIFICATIONS

FOR

COAL-TAR PITCH FOR STONE BLOCK FILLER.[1]

Serial Designation: D 112 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Properties.

1. The coal-tar pitch shall conform to the following requirements:

(*a*) Water .... 0.00 per cent

(*b*) Specific gravity at 25°/25° C. (77°/77° F.) .... 1.23 to 1.33

(*c*) Softening point[2] (Cube-in-Water Method) ......
46 to 57° C. (115 to 135° F.)

(*d*) Distillation test:

Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.) .... not more than 10.00 per cent.
Residue, by weight .... not less than 90.00 "

(*e*) Specific gravity at 25°/25° C. (77°/77° F.) of total distillate to 300° C. (572° F.) .... not less than 1.03

(*f*) Softening point (Cube-in-Water Method) of residue from distillation test .... not more than 75° C. (167° F.)

(*g*) Ductility at 50 to 100 penetration, at 25° C. (77° F.).
not less than 50 cm.

NOTE.—The penetration of the pitch shall be brought within the range of 50 to 100 penetration by heating in an open vessel with frequent stirrings at a temperature of not over 350° F.

(*h*) Free carbon .... 20.00 to 35.00 per cent

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] The Softening Point (Cube-in-Water Method) specified should have a range of not over 10° F. within the above limits. The range, within the limits of 115 to 135° F. should vary with the use of the material, for example, if used in admixture with sand, in a northern locality or a southern locality. The softening point range, within the above limits, should also vary according to the character of the paving.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Bituminous Materials (Serial Designation: D 114 - 21 T);[1]

(*b*) *Specific Gravity:* Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (Serial Designation: D 70 - 20 T);[2]

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test (for Softening Point of Tar Products (Cube-in-Water Method) Serial Designation: D 61);[3]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*f*) *Free Carbon:* Standard Method of Test for Soluble Bitumen (Serial Designation: D 4).[3]

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 706 (1921).

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 764 (1920).

[3] 1921 Book of A.S.T.M. Standards

[4] See p. 807.

TENTATIVE METHOD OF DECANTATION TEST
FOR
SAND AND OTHER FINE AGGREGATES.[1]

Serial Designation: D 136 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope. 1. This method of test covers the determination of the total quantity of silt, loam, clay, etc., in sand and other fine aggregates.[2]

Apparatus. 2. The pan or vessel to be used in the determination shall be approximately 9 in. (230 mm.) in diameter and not less than 4 in. (102 mm.) in depth.

Treatment of Sample. 3. The sample must contain sufficient moisture to prevent segregation and shall be thoroughly mixed. A representative portion of the sample sufficient to yield approximately 500 g. of dried material, shall then be dried to a constant weight at a temperature not exceeding 110° C. (230° F.).

Procedure. 4. The dried material shall be placed in the pan and sufficient water added to cover the sample (about 225 cc.). The contents of the pan shall be agitated vigorously for 15 seconds, and then be allowed to settle for 15 seconds, after which the water shall be poured off, care being taken not to pour off any sand. This operation shall be repeated until the wash water is clear. As a precaution, the wash water shall be poured through a 200-mesh sieve and any material retained thereon returned to the washed sample. The washed sand shall be dried to a constant weight at a temperature not exceeding 110° C. (230° F.) and weighed.

Calculation of Results. 5. The results shall be calculated from the formula:

$$\text{Percentage of silt, clay, loam, etc.} = \frac{\text{Original dry weight} - \text{weight after washing}}{\text{Original dry weight.}} \times 100$$

Check Determination. 6. When check determinations are desired, the wash water shall be evaporated to dryness, the residue weighed, and the percentage calculated from the formula:

$$\text{Percentage of silt, loam, clay, etc.} = \frac{\text{Weight of residue}}{\text{Original dry weight}} \times 100$$

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1923, to Mr. J. C. Pearson, Secretary of Committee C-9 on Concrete and Concrete Aggregates, Bureau of Standards, Washington, D. C.

[2] This determination of the percentage of silt, clay, loam, etc., will include all water-soluble material present, the percentage of which may be determined separately if desired.

TENTATIVE METHOD OF MECHANICAL ANALYSIS OF SUBGRADE SOILS.[1]

Serial Designation: D 137 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope. 1. This method covers the determination of the amount of sand, silt, clay and suspension clay[2] in subgrade soils.

Treatment of Sample. 2. The sample as received shall be dried in an oven at a temperature not to exceed 100° C. (212° F.) and shall then be broken up in a mortar by means of a rubber-covered pestle, care being taken not to break any fragments of rock or sand. The sample shall then be passed through a ¼-in. screen and the material passing this screen further pulverized by rolling out in a thin layer on a rubber pad, using a rubber-covered roller.

Apparatus. 3. The apparatus shall consist of a wide-mouthed cylindrical glass jar of at least 10 liters capacity; a soil centrifuge with a four or eight-tube head of such diameter that a speed of 1500 r.p.m. will exert a centrifugal force approximately 500 times the force of gravity; four centrifuge tubes of 100-cc. capacity; and a chemical balance sensitive to 0.001 g.

Procedure. 4. A 25-g. sample of soil passing the 10-mesh sieve and prepared as specified in Section 2 shall be placed in a beaker with approximately 500 cc. of distilled water, gradually brought to the boiling point and shall then be allowed to stand for about 24 hours. Care should be taken not to boil for more than two or three minutes, as continued boiling tends to cause coagulation. After standing for approximately 24 hours, the material in the beaker shall be thoroughly brushed and dispersed with a stiff brush for two or three minutes and then allowed to stand for eight minutes. The supernatant liquid shall then be decanted into a vessel having a capacity of about 10 liters. About 500 cc. of ammoniated water (concentration 1 : 500) shall be added to the material remaining in the beaker and the brushing repeated as before. After standing for eight minutes, the supernatant liquid shall be decanted into the large vessel. This process shall be repeated until the supernatant liquid becomes clear after eight minutes sedimentation. The sand and silt will have become separated from the clay and suspension clay, which are contained in the large vessel. The material in the beaker shall be transferred to an evaporating dish, dried in an oven to constant weight at a temperature of 100° C. (212° F.), cooled, and a mechanical analysis made, using 20, 50, 100 and 200-mesh sieves. The material retained on each sieve shall be recorded as a percentage of the original 25-g. sample, and that which passes the 200-mesh sieve shall be recorded as the percentage of silt in the original sample.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] The determination of the percentage of suspension clay by this method will include any water-soluble material present which may be determined separately if desirable.

The volume of the liquid in the large vessel shall be brought up to at least 10 liters by the addition of ammoniated water, and the vessel thoroughly shaken until all material is in suspension. Seventy cubic centimeters shall then be siphoned from this vessel at a depth of about one-half the total depth of the liquid into each of four centrifuge tubes. The tubes shall then be mounted in the centrifuge and run for 30 minutes at a speed which, for the diameter of the head used, will exert a centrifugal force approximately 500 times the force of gravity. The material which has been thrown out of the liquid by centrifuging shall be classified as clay and that which remains in suspension as suspension clay. The solution containing the suspension clay shall be decanted, evaporated to dryness, and the weight of the suspension clay determined. The clay remaining in the tube shall also be dried and weighed.

The weight of suspension clay is determined from the liquid in four tubes, or 280 cc.; consequently this weight must be multiplied by the factor obtained by dividing the total volume used by 280 cc. in order to obtain the total amount of suspension clay in the original 25-g. sample. The weight of clay is determined from the clay in one tube, or 70 cc.; therefore the total volume divided by 70 cc. gives the factor by which this weight should be multiplied to give the total clay in the original 25-g. sample. The total weights of clay and suspension clay thus obtained shall be converted into percentages of the original 25-g. sample.

TENTATIVE METHOD OF TEST
FOR
CONSISTENCY OF PORTLAND-CEMENT CONCRETE FOR PAVEMENTS OR FOR PAVEMENT BASE.[1]

Serial Designation: D 138 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope. 1. This test covers the method to be used both in the laboratory and in the field for determining consistency of concrete[2] to be used for concrete pavements or for concrete base for pavements.

Apparatus. 2. The test specimen shall be formed in a mold of No. 16 gage galvanized metal in the form of the lateral surface of the frustrum of a cone with the base 8 in. in diameter, the upper surface 4 in. in diameter, and the altitude 12 in. The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mold shall be provided with foot pieces and handles as shown in Fig. 1.

Sample. 3. When the test is made at the mixer, the sample shall be taken from the pile of concrete immediately after the entire batch has been discharged. When testing concrete that has been hauled from a central mixing plant, the sample shall be taken from the concrete immediately after it has been dumped on the subgrade.

Procedure. 4. The mold shall be placed on a flat, non-absorbent surface, such as a smooth plank or a slab of concrete, and the operator shall hold the form firmly in place, while it is being filled, by standing on the foot pieces. The mold shall be filled to about one-fourth of its height with the concrete which shall then be puddled, using 20 to 30 strokes of a $\frac{1}{2}$-in. rod pointed at the lower end. The filling shall be completed in successive layers similar to the first and the top struck off so that the mold is exactly filled. The mold shall then be removed by being raised vertically, and at exactly three minutes after being filled. The molded concrete shall then be allowed to subside until quiescent and the height of the specimen measured.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] This test is not considered applicable when there is a considerable amount of coarse aggregate over 2 in. in size in the concrete. The committee is now working on a method suitable for determining the consistency of concrete using aggregate over 2 in. in size.

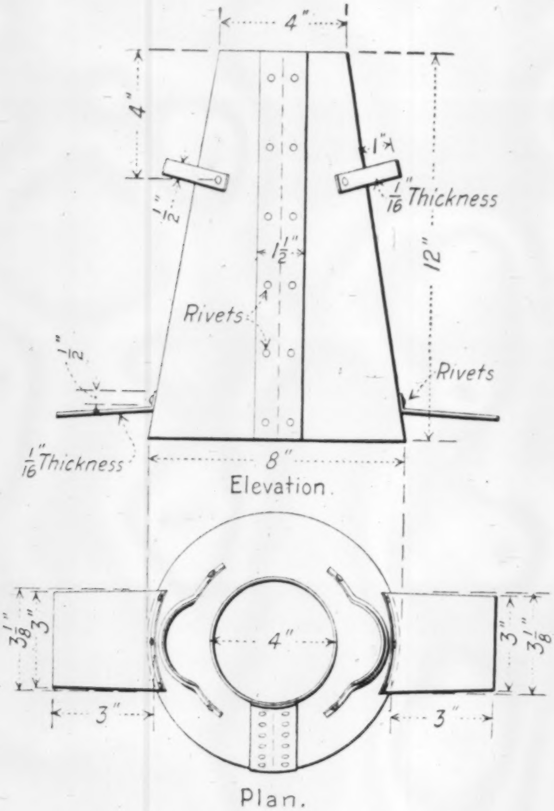
4"
4"
1"
$\frac{1}{16}$" Thickness
$\frac{1}{2}$"
12"
$1\frac{1}{2}$"
Rivets
$\frac{1}{2}$"
Rivets
$\frac{1}{16}$" Thickness
8"
Elevation.
$3\frac{1}{8}$"
3"
4"
3"
$3\frac{1}{8}$"
3"
3"
Plan.

FIG. 1.

Slump. 5. The consistency shall be recorded in terms of inches of subsidence of the specimen during the test, which shall be known as the slump.

Slump = 12 — inches of height after subsidence

TENTATIVE METHOD OF TEST
FOR
DUCTILITY OF BITUMINOUS MATERIALS.[1]

Serial Designation: D 113 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Definition. 1. The ductility of an asphalt cement or semi-solid bitumen is the distance to which it will elongate before breaking when two ends of a briquette of the material are pulled apart at a specified rate of speed and at a specified temperature. When the conditions of the test are not specifically mentioned, the rate and the temperature are understood to be 5 cm. per minute at 25° C. (77° F.).

APPARATUS.

Mold. 2. The mold shall be as shown in Fig. 1. It shall be made of brass, the ends, b and b′, being known as clips, and the parts, a and a′, as sides of the mold. The dimensions of the mold shall be as follows:

Total length (internal)	7.45 - 7.55 cm.
Distance between clips	2.97 - 3.06 "
Width of clips at mouth	1.98 - 2.02 "
Width of briquette at minimum cross-section (half way between clips)	0.99 - 1.01 "
Thickness of briquette throughout	0.99 - 1.01 "

Water Bath. 3. The water bath shall be maintained at a temperature not varying more than 0.1° C. from 25° C. (77° F.). The volume of water shall be not less than 10 liters and the sample shall be immersed to a depth of not less than 10 cm. and shall be supported on a perforated shelf not less than 5 cm. from the bottom of the bath.

Testing Machine. 4. Any apparatus may be used for pulling the briquette of bitumen apart that is so constructed that the briquette will be continuously immersed in water and the two clips pulled apart at a uniform rate of speed of 5 cm. per minute.

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[1] Criticisms of this Tentative Method are solicited and should be directed preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

PROCEDURE.

Melting and Molding.

5. The asphalt cement or bituminous material to be tested shall be completely melted at such a temperature that it will be thoroughly fluid—with ordinary paving asphalt cement this is about 160° C. (320° F.). It shall then be strained through a 50-mesh sieve and, after a thorough stirring, poured into the mold. The mold shall be assembled on a brass plate and so as to prevent the material under test from sticking, the surface of the plate and the interior surfaces of the side pieces *aa'* of the mold shall be thoroughly amalgamated. In filling the mold care shall be taken not to disarrange the parts and thus distort the briquette. In filling, the material shall be poured in a thin stream back and forth from end to end of the mold until it is more than level full. It shall be left to cool to room temperature and then placed in water maintained at 25° C. (77° F.) for 30 minutes, after which the excess of bitumen shall be cut off by means of a hot putty knife or spatula so that the mold shall be just level full.

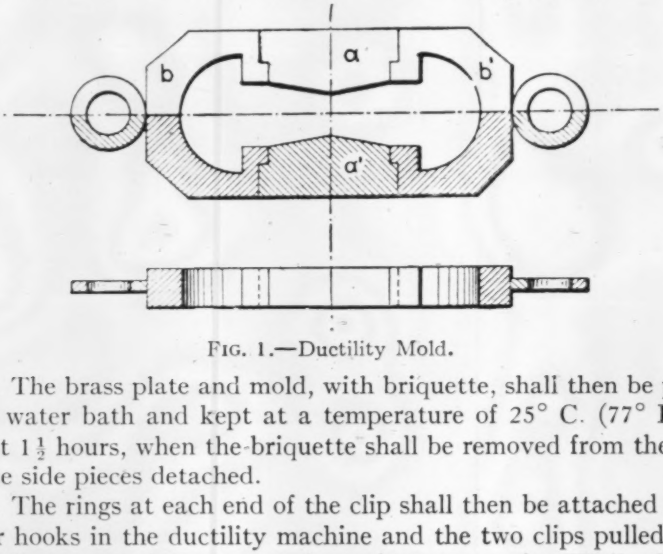

FIG. 1.—Ductility Mold.

Keeping at Standard Temperature.

6. The brass plate and mold, with briquette, shall then be placed in the water bath and kept at a temperature of 25° C. (77° F.) for at least 1½ hours, when the briquette shall be removed from the plate and the side pieces detached.

Testing.

7. The rings at each end of the clip shall then be attached to the pins or hooks in the ductility machine and the two clips pulled apart at a uniform rate of 5 cm. per minute (±5 per cent). While the test is being made, the water in the tank of the ductility machine shall cover the sample by at least 2.5 cm. and shall be kept continuously at a temperature within 0.5° C. of 25° C. (77° F.). When the specimen of bituminous material breaks, the distance from the original position of the clip before pulling to its present position shall be measured, and shall be known as the ductility. The average of three tests shall be taken, excepting that any abnormal result shall be rejected.

TENTATIVE METHOD OF FLOAT TEST
FOR
BITUMINOUS ROAD MATERIALS.[1]

Serial Designation: D 139-22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. APPARATUS.

Float. 1. The float (Fig. 1) shall be made of aluminum or aluminum alloy and shall be in accordance with the following requirements:

	MINIMUM.	NORMAL.	MAXIMUM.
Weight of float, g.	37.80	37.95	38.10
Total height of float, mm.	34.0	35.0	36.0
Height of rim above lower side of shoulder, mm.	26.5	27.0	27.5
Thickness of shoulder, mm.	1.2	1.4	1.6
Diameter of opening, mm.	10.7	11.1	11.5
Height of rim above water with load of 5.5 g., mm.	7.0	8.5	10.0

Collar. 2. The collar (Fig. 1) shall be made of brass and shall be in accordance with the following requirements:

	MINIMUM.	NORMAL.	MAXIMUM.
Weight of collar, g.	9.9	9.95	10.0
Over-all height of collar, mm.	22.3	22.5	22.7
Inside diameter at bottom, mm.	12.78	12.80	12.82
Inside diameter at top, mm.	9.66	9.68	9.70

Thermometer. 3. The thermometer shall conform to the following specifications:

Total length	370 – 400 mm.	(14.57 – 15.75 in.)
Diameter	6.5 – 7.5 "	(0.256 – 0.295 ")
Bulb length	Not over 14 "	(Not over 0.55 ")
Bulb Diameter	4.5 – 5.5 "	(0.177 – 0.217 ")

The scale shall be engraved upon the stem of the thermometer, shall be clear cut and distinct, and shall run from 0 to 80° C. (32 to 176° F.) in $\frac{1}{5}$° C. divisions. It shall commence not less than 75 mm. (2.95 in.) above the bottom of the bulb. The thermometer shall be furnished with an expansion chamber at the top and have a ring for attaching tags. It shall be made of a suitable quality of glass and be so annealed as not to change its readings under conditions of use. It shall be correct to 0.25° C. (0.45° F.) as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the U. S. Bureau of Standards.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

Bath. 4. The minimum diameter of the bath shall be twice the diameter of the float; the minimum depth of water shall be equal to the diameter of the bath.

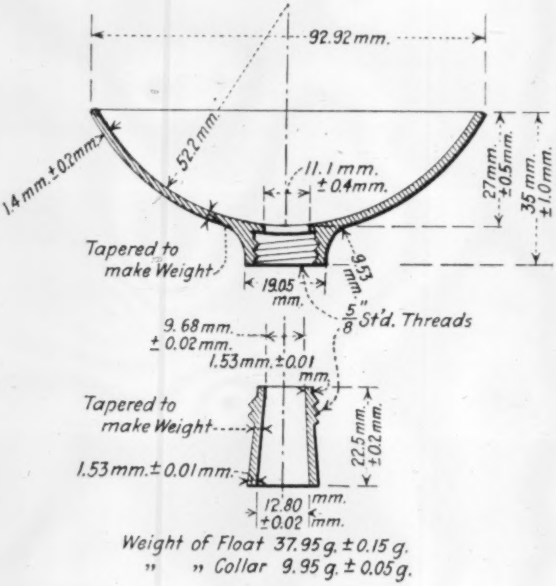
92.92 mm.
52.2 mm.
1.4 mm. ± 0.2 mm.
11.1 mm. ± 0.4 mm.
27 mm. ± 0.5 mm.
35 mm. ± 1.0 mm.
Tapered to make Weight
9.53 mm.
19.05 mm.
5/8" St'd. Threads
9.68 mm. ± 0.02 mm.
1.53 mm. ± 0.01 mm.
Tapered to make Weight
22.5 mm. ± 0.2 mm.
1.53 mm. ± 0.01 mm.
12.80 mm. ± 0.02 mm.
Weight of Float 37.95 g. ± 0.15 g.
" " Collar 9.95 g. ± 0.05 g.

FIG. 1.

II. PREPARATION OF SAMPLE.

Preparation of Sample. 5. The sample shall be completely melted at the lowest possible temperature, heating only sufficiently to bring the product into a fluid condition but not above 350° F., and stirred thoroughly until it is homogeneous and free fom air bubbles.

The brass collar shall be placed with the smaller end on a brass plate which has been previously amalgamated with mercury by first rubbing it with a dilute solution of mercuric chloride or nitrate and then with mercury. The sample shall be poured into the collar in any convenient way until slightly more than level with the top. It shall be cooled to room temperature, placed in water maintained at

5° C. for 5 minutes, after which the surplus material shall be removed by means of a spatula, or steel knife, which has been slightly heated. The collar and plate shall then be placed in tin cup containing ice water maintained at 5° C., ± 1° C., and left in this bath for at least 15 minutes.

III. PROCEDURE.

Procedure.

6. (*a*) The bath shall be filled with water and the water heated to the temperature at which the test is to be made. This temperature shall be accurately maintained and shall at no time throughout the test be allowed to vary more than 0.5° C. from the temperature specified.

(*b*) After the material to be tested has been kept in the ice water for not less than 15 minutes nor more than 30 minutes, the collar with its contents shall be removed from the plate and screwed into the aluminum float and immersed in water at 5° C. for one minute. Any water shall then be removed from the inside of the float and the latter immediately floated in the warm bath. As the plug of material becomes warm and fluid, it is forced upward and out of the collar until the water gains entrance into the saucer and causes it to sink.

(*c*) The time in seconds between placing the apparatus on the water and when the water breaks through the material shall be determined by means of a stop watch, and shall be taken as a measure of the consistency of the material under examination.

NOTE.—Special precaution should be taken to insure the collar fitting tightly into the float and to see that there is no seepage of water between the collar and float during the test.

TENTATIVE METHODS OF SAMPLING BITUMINOUS MATERIALS.[1]

Serial Designation: D 140 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

General Directions

1. Samples may be taken for either of two purposes:

(*a*) To represent as nearly as possible an average of the bulk of the material sampled.

(*b*) To ascertain the maximum variation in characteristics which the material may possess. In either case they shall be obtained by methods hereinafter described.

2. (*a*) Care shall be taken that the samples are not contaminated with dirt or any other extraneous matter and that the sample containers are perfectly clean and dry before filling.

(*b*) Immediately after filling, the sample containers shall be tightly closed and properly marked for identification on the container itself or on a linen tag attached to the container.

Time and Place.

3. (*a*) Whenever practical, bituminous materials shall be sampled at the point of manufacture, and at such time as to allow the tests, controlling acceptance or rejection, to be made in advance of shipment.

(*b*) When impracticable to take samples at the point of manufacture, they should be taken from the shipment immediately upon delivery.

Size of Samples.

4. For routine laboratory examination of acceptability of a given lot, not less than one quart of material should be submitted which should be representative of the average sample collected as hereinafter described.

Containers.

5. Containers for liquid bituminous materials shall be small-mouth cans with cork-lined screw caps. Containers for semi-solid and solid materials shall be friction top cans.

I. SAMPLING AT PLACE OF MANUFACTURE.

From Bulk Storage.

6. The inlet and outlet to the storage tank shall be sealed and a 1-gal. sample drawn from the top, middle and bottom contents. The sample may be taken from drain cocks on the side of the tank, if such

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

are available. Enough material should be discarded to insure a representative sample. Otherwise, samples may be taken by lowering, weighted bottles or cans into the material. The bottle or can should be fitted with a stopper which can be removed by a string or wire attached to it after it has been lowered to the proper depth. The three samples from bulk storage shall be tested separately for consistency in order to detect stratification. They may then be combined and thoroughly mixed for other tests that may be required.

Sampling during Loading.

7. Where tank cars, distributors or barrels are being filled, samples may conveniently be taken from the pipe line through which the material is flowing, as hereinafter described.

(*A*) *When Material is Pumped Under Pressure.*

8. The sampling pipe shall be inserted into a rising section of the pipe line on the discharge side of the pump. The sampling pipe shall be not more than one-eighth the diameter of the line pipe and its opening should be turned at an angle of 90 deg. facing the flow of the liquid. This pipe shall be provided with a plug cock and shall discharge into a receiving drum of 50-gal. capacity. The plug cock shall be so adjusted that there is a steady continuous flow of bituminous material through it and shall be so regulated that the receiver will fill in the same time that is required to make the entire pumping. In the case of semi-solid materials, the receiver shall be provided with a steam coil which shall keep the contents at a temperature just above the liquefying point. At completion of the pumping, the receiver shall be thoroughly agitated, and a 1-qt. sample taken therefrom. The sampling shall be so regulated that for each 1000 gal. of material pumped, at least 1 gal. of sample is taken; but 40 gal. shall be the limit required for any one cargo.

Care should be taken that the drip cock, after once having been set, allows a constant flow during the pumping.

This method is also applicable to gravity flows where the pipe line is completely filled by the outflowing liquid and has a rising section.

(*B*) *When Materials Flow by Gravity.*

9. Materials flowing by gravity through pipes which are not completely filled may be sampled by taking dipperfuls at the outlet at frequent and regular intervals. These samples shall be combined and the total sample shall be not less than 0.1 per cent of the whole material. The samples shall be collected in a receiver and resampled as described in Section 8.

II. SAMPLING AT POINT OF DELIVERY.

Tank Cars. 10. Samples may be taken by means of a weighted bottle or can, as described in Section 6, or from the unloading pipe line as described in Section 7

Liquid bituminous materials shall be sampled before heating. Semi-solid or solid bituminous materials shall be rendered fluid by heating. Sampling should be so conducted as to eliminate the possibility of adventitious water resulting from leaky steam heating coils, rain or snow.

Distributors. 11. Samples may be taken from distributors by means of a weighted bottle or can, as described in Section 6. One sample shall be sufficient.

Barrels and Drums. 12. (*a*) Samples of liquid bituminous materials from barrels or drums may be secured by taking 1 qt. of material from one out of every ten packages, combining and thoroughly mixing these samples and then removing an average sample from the combined material.

(*b*) Sampling of solid or semi-solid materials from barrels is more difficult to accomplish properly. It is recommended that samples be taken from each car lot, but if this sample fails to meet the specification requirements, then a sample shall be taken from each batch represented or from one out of each twenty barrels, samples to be taken from at least 3 in. below the surface and at least 3 in. from the side of the barrel. A clean hatchet may be used if the material is hard enough to shatter and a broad stiff putty knife if the material is soft. The samples so taken shall be melted and thoroughly mixed and an average sample taken from the combined material for examination.

TENTATIVE METHOD OF TEST
FOR
FUSIBILITY OF COAL ASH.[1]

Serial Designation: D 22 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1919; REVISED, 1922.

APPARATUS.

Standard Furnace.—The No. 3 melter's furnace of the American Gas Furnace Co., shall be used, or its equivalent.

The No. 3 melter's furnace is a type of pot furnace especially suitable for fusion determination in that the burners, three in number, are on a tangent near the base of the furnace, thus producing a rotary flame which completely surrounds the crucible in which the cones are placed. The whirling flame heats the crucible uniformly and when the furnace is operated with excess gas supply, a reducing atmosphere is maintained within the crucible, which condition gives the lowest point at which the ash fuses. The air should be supplied at an approximate pressure of 3 lb. per sq. in., and either natural or artificial gas may be used.

The furnace proper consists of three easily replaceable fire-clay parts, namely, a lower cylinder containing the three tangential tuyeres, and forming the bottom of the furnace, a removable upper cylinder 7 in. in internal diameter and 7 in. high, and a cover plate 1½ in. thick, having a vent hole in the center for the flue gas.

The stock design should be modified by furnishing the upper cylinder with two holes in the side: a 2-in. observation hole with its center 4 in. from the top of the cylinder (excluding cover plate), and a 1-in. thermocouple hole 90 deg. to the right of the observation hole; the bottom of these two holes being in the same horizontal plane. The interior of the furnace is cylindrical and approximately 7 in. in diameter and 11 in. high.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

This method, when adopted as standard, will be added to the present Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22-21), 1921 Book of A.S.T.M. Standards.

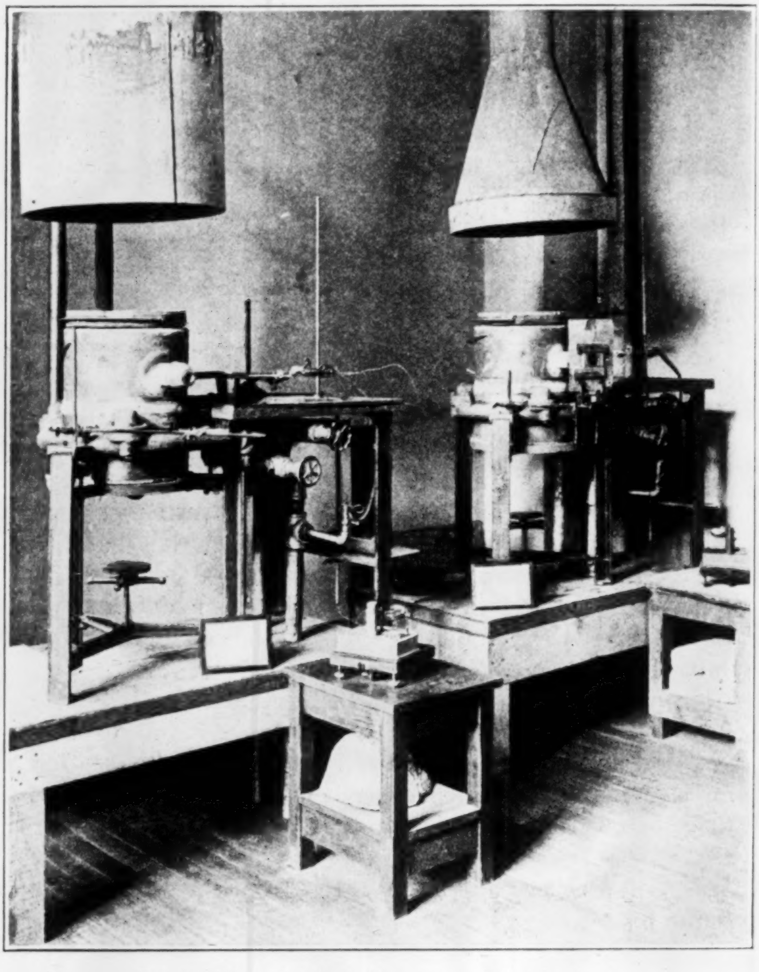

FIG. 1.—No. 3 Melter's Furnace and Accessories.

A counter-balanced sheet-iron canopy is connected with a telescopic 8-in. flue to an exhaust system to conduct the hot gases out of the room. Two melter's No. 3 furnaces and accessories are shown in Fig. 1.

The joint between the upper and lower cylinder is made fairly gas-tight by spreading on the top of the lower cylinder a thick paste of alundum cement to a depth of $\frac{1}{2}$ in. and then firmly pressing the upper cylinder into place. The outer part of the joint is also smoothed over with alundum cement. The fire-clay furnace cylinders and cover will withstand a temperature of about 1650° C.

Refractory Crucibles.—The interior of the furnace as arranged for making a test is shown in Fig. 2. The ash cones *d* are supported on a plate of alundum cement serving as a cover for crucible *c* which is a Denver fire-clay hard burned crucible, $3\frac{1}{2}$ in. high and $2\frac{7}{8}$ in. in diameter at the top. The cone-supporting crucible is within the crucible *b* which with the cover *g* serves as a muffle. Crucible *b* is a Denver fire-clay hard burned crucible, No. K, $7\frac{1}{4}$ in. high and $4\frac{3}{4}$ in. in diameter at the top, and rests on fire-clay support *a*. This crucible should be provided with two holes in the side, an observation hole $1\frac{3}{4}$ in. in diameter

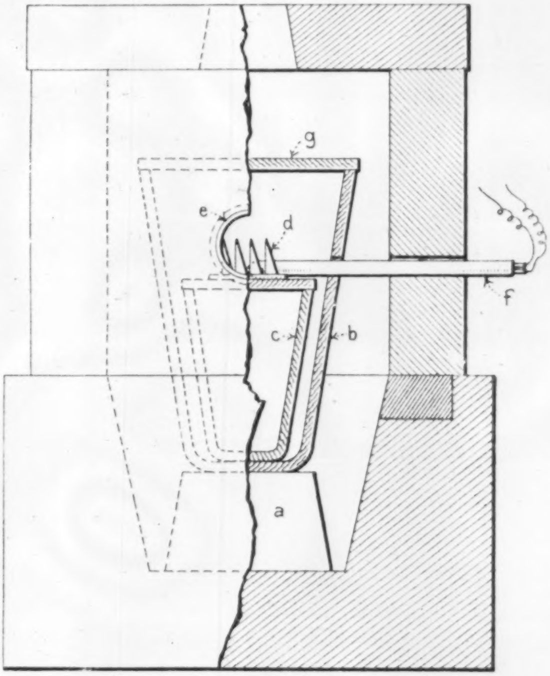

FIG. 2 —Section of No. 3 Melter's Furnace Arranged for Fusion Tests.

with its center 2 in. from the top of the crucible and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottom of this hole should be in the same horizontal plane as the bottom of the observation hole. The hard burned fire-clay crucibles will not withstand a temperature exceeding 1500° C. The average life of a fire-clay crucible under these conditions is about six runs.

Corundite crucibles and covers of the Massillon Stone and Fire Brick Co., or their equivalent, are longer lived than the fire-clay crucibles, being good for about fifty runs. A special form used by the Bureau of Mines is 3 in. inside diameter, 4½ in. high outside, with a wall thickness of about ½ in. Crucibles should be provided with two holes in the side, an observation hole 2 in. in diameter with its center 1¾ in. above the bottom of the crucible, and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottom of this hole should be in the same horizontal plane as the bottom of the observation hole.

Observation Tube.—A fused silica or refractory porcelain tube *f*, 1⅞ in. in external diameter and 6 in. long, is placed in the 2 in. observation hole of the furnace, the inner end being flush with the inside furnace wall and the other end projecting out of the furnace. A brass sleeve carrying a thin glass window is slipped on the outer end of the observation tube to prevent the escape of burning gas, which would interfere with a convenient observation of the cones.

Blowing Tube.—At furnace temperatures above 1000° C., it is very difficult to observe the ash cones. A Marquadt, Usalite, Impervite or equal quality porcelain blowing tube ¼ in. in diameter is inserted through the same hole as the thermocouple tube. This tube has small perforations along one side by which air may be forced upon the cones at the time of making the observation, thus momentarily cooling the ash cones and rendering them visible. The blowing tube is connected to the compressed air line by means of rubber tubing and the air is let into the tube at the time of observation by means of a pinchcock.

Brass Cone Mold.—A brass cone mold for making ash cones, ¾ in. high and ¼ in. at each side of base, which is an equilateral triangle, is illustrated in Fig. 3.

Pyrometer.—Temperature measurements may be made with a thermocouple of platinum and platinum-rhodium, protected from the furnace gases by a glazed Marquadt, Usalite, Impervite or equal quality porcelain tube, and a high-resistance millivoltmeter; or with an optical pyrometer preferably of the Leeds and Northrup, or Wanner type. This equipment should be checked frequently by mounting small pieces of pure gold or nickel wire or foil in the same manner as the cones. With a strong reducing atmosphere 1452° C. should be obtained for the melting point of the nickel and 1063° C. for the gold. The pyrometer equipment should also from time to time be standardized through the temperature range for which it is used, by a suitably equipped standardizing laboratory such as that of the U. S. Bureau of Standards.

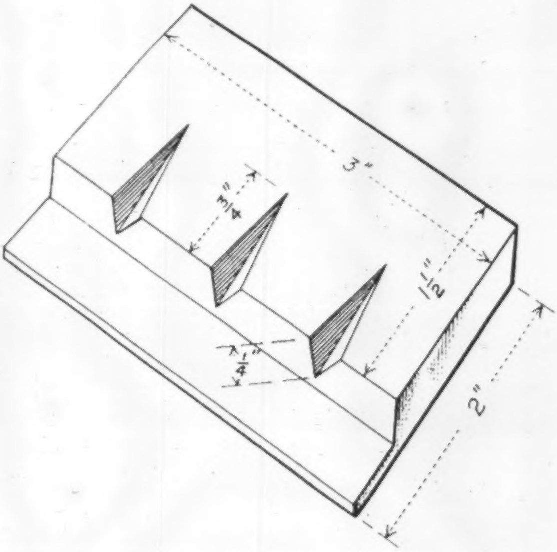

FIG. 3.—Brass Cone Mold.

PREPARATION OF COAL ASH.

Spread out 50 to 100 g. of 60-mesh coal on a 6-in. fire-clay roasting dish, and completely convert to ash in a muffle furnace at a temperature of 800 to 900° C. Transfer 5 to 10 g. of this ash to an agate mortar[1] and grind to a fineness of 200 mesh. Then place the ash in a silica or porcelain capsule, $\frac{5}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, and ignite for a period of two hours in a current of oxygen, at a temperature of 800 to 850° C. This ignition is made to insure complete and uniform oxidation of the ash.

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[1] A mechanical agate-mortar grinder will save time where many determinations are made.

PREPARATION OF CONES.

Moisten the ignited ash with a 10-per-cent dextrin solution and work into a plastic mass with a spatula. Mold the plastic material into small triangular pyramids $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. wide at the side of the base. The pyramids are made by firmly pressing the plastic material with a steel spatula into a brass mold of the dimensions mentioned, the mold being similar to that shown in Fig. 3. Strike off the surface smooth and remove the cone from the mold by applying a small knife blade at the base. Mount the cones when dry in a refractory base composed of a mixture of equal parts of kaolin and calcined alumina. Moisten the base mixture to make it workable, and spread a part of it out on a sheet-iron plate. Then mount the cone in a vertical position in a small hole made in the base, and put base material into the hole around the bottom of the cone to fill the crevices and make the cone stand firmly. Usually five cones are mounted in one base in the manner shown in Fig. 4. Dry the sheet-iron plate with the test piece on a hot plate. Ignite the cones at a dull red heat for 30 minutes in an open muffle to remove the carbonaceous material.

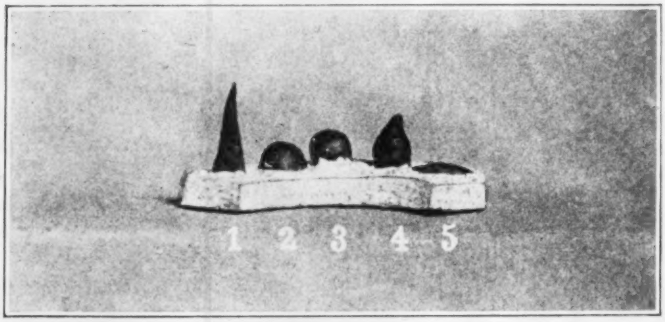

FIG. 4.—Typical Forms of Cones Fused in the No. 3 Melter's Furnace.

METHOD OF HEATING.

Place the test piece in the muffle crucible of the melter's furnace in the position shown in Fig. 2, place the loosely fitting cover *g* on the crucible, and ignite the gas. It is necessary to let the gas burn about 10 minutes to heat the furnace parts before the large cover plate of the furnace is replaced; otherwise the flame is apt to blow out. During this time increase the flow of gas and air sufficiently to cause the combustion to take place just above the tuyeres and yet maintain a yellowish flame at least 6 in. above the opening in the furnace cover plate. While such a flame is maintained above the furnace gradually increase the temperature by a suitable adjustment of gas and air to 800° C., then reduce the rate of heat increase to not less than 5° C. and not more than 10° C. per minute. Maintain this rate until the end of the test. It is also important that the 6 in. reducing flame be maintained at the furnace vent throughout the test, if possible, and at all events up to a temperature of 1450° C. Temperatures above 1450° C. require larger proportions of air to gas; however, a strongly reducing atmosphere is not so essential at the higher temperatures, as refractory ashes, owing to their low iron-oxide content, are only slightly affected by oxidizing or reducing atmospheres. After a test has been completed, turn the supply of gas and air off gradually to avoid cracking the muffle crucible.

The softening temperature is defined as the temperature at which the cone has fused down to a spherical lump, as shown in cones 2 and 3 of Fig. 4. Cone 4 has almost reached the softening temperature.

The permissible differences of the softening temperature point in duplicate determinations are as follows:

Same analyst	30° C.
Different analysts	50° C.

NOTES.

Critical points other than the softening temperature, that may be observed during the test, and which may be of value are as follows:

The Initial Deformation Temperature.—The temperature at which the first rounding or bending of the apex of the cone takes place, as shown in cone 1 of Fig. 4. Such bending must not be confused with a shrinking or warping of the cone.

The Fluid Temperature.—The temperature at which the cone has spread out over the base in a flat layer, as represented by cone 5 of Fig. 4

TENTATIVE METHOD OF SHATTER TEST
FOR
COKE.[1]

Serial Designation: D 141 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. APPARATUS.

Shatter Test Machine.

1. The shatter test machine shall consist of a box 18 in. in width, 28 in. in length, and approximately 15 in. in depth, supported above a rigidly mounted cast-iron or steel plate, not less than ½ in. in thickness, 38 in. in width, and 48 in. in length. The inside of the bottom of the box shall be 6 ft. above the plate. The bottom of the box shall consist of two doors hinged lengthwise and latched so that they will swing open freely and not impede the fall of the coke. Boards about 8 in. in height should be placed around the plate so that no coke is lost. To prevent the breakage of coke, which may occur while placing the sample in the box, the box shall be constructed so that it can be lowered to a convenient level, which is best done by means of a pulley and counter-weight.

Screens.

2. For determining the breakage of coke, square-mesh screens with the following openings shall be used: 2 in., 1½ in., 1 in., and ½ in. A circular screen, 2 ft. in diameter, is satisfactory.

II. SAMPLING.

Place of Sampling.

3. (*a*) If the shatter test is to be used to indicate the probable breakage of coke on handling, the sample should be taken before the coke is subjected to possible breakage resulting from screening and loading into cars. In the case of by-product coke, the sample should be collected from the coke wharf; while samples of beehive coke should be collected as it is delivered from the ovens.

(*b*) If the shatter test is to be used to indicate the fitness of the coke for furnace or cupola use, the sample should be collected at the point of delivery.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

Sampling at Source.

4. (*a*) *By-Product Coke.*—About 75 lb. of representative pieces of coke, none of which would in any position pass through a 2-in. square-mesh screen, shall be selected from the coke wharf for each test. This is best accomplished by dividing the coke on the wharf into approximately equal areas, and selecting an equal number of pieces from each area. Each piece selected shall be approximately equal in length to one-half the width of the coke-ovens, and should show a "cauliflower" end produced at the walls of the ovens, and an "inner" end produced at the center of the ovens.

(*b*) *Beehive Coke.*—About 75 lb. of representative pieces of coke shall be selected for each test as the coke is drawn from the ovens. This is best done by selecting full-length pieces, or their equivalent, as the coke is being drawn from previously determined points in the oven, so that they include pieces from the front, sides, center, and back. If the individual pieces as taken from the ovens are too large and bulky, the 75-lb. sample shall be collected by removing three small pieces from each large piece—one from the top, the middle, and the bottom. The sample finally collected should be composed of an equal number of pieces showing top, middle, and bottom. None of the pieces comprising the sample shall in any position pass through the 2-in. square-mesh screen.

Sampling at Delivery.

5. *By-Product and Beehive Coke.*—The sample is best collected as the coke is delivered from the railroad cars into the bins. This may be accomplished by inserting a scoop of 10 to 15-lb. capacity in the coke stream at regular intervals during the period of unloading. The sample collected shall be large enough to give about 75 lb. of coke pieces, none of which would in any position pass through a 2-in. square-mesh screen.

As it is very difficult to collect a representative sample from coke exposed in bins and cars, care should be taken to take pieces representing the entire exposed area, if sampling must be done in this manner. This is best accomplished by dividing the exposed surface to be sampled into approximately equal areas, and selecting an equal number of pieces from each area. Approximately 75 lb. of representative pieces, none of which would in any position pass through a 2-in. square-mesh sieve, shall be collected.

III. PROCEDURE.

Procedure.

6. About 50 lb. of the sample shall be placed in the box of the coke shatter test machine, the coke levelled, the box raised, and the coke dropped four times on the plate, the small material produced being returned each time to the box with the large coke. To prevent

breakage of the coke, the box should be lowered to a convenient height when transferring the sample into it. After the fourth drop, the material shall be successively run through the screens described. The coke should be screened in such increments as will allow all pieces to be in direct contact with the screen openings.

In screening, care should be taken to prevent breakage of the coke pieces. The screen shall be shaken gently until all of the pieces are in direct contact with the meshes. The coke remaining on each screen, and that which passes through, shall be weighed separately. If the sum of these weights shows a loss of over 1 per cent, the test shall be rejected and another made.

The results of the shatter test shall be reported as follows:

SCREEN, SIZE.	
Retained on 2 in.	.... per cent
Retained on $1\frac{1}{2}$ in., passing 2 in.	.... per cent
Retained on 1 in., passing $1\frac{1}{2}$ in.	.... per cent
Retained on $\frac{1}{2}$ in., passing 1 in.	.... per cent
Passing $\frac{1}{2}$ in.	.... per cent

Number of Tests.

7. Since the average probable error of a single shatter test determination is approximately 2 per cent, it is advisable to make several tests and report the average result.

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO COAL.[1]

Serial Designation: D 142 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Proximate Analysis.—The quantitative determination, by fixed procedure, of ingredients not elementary or of definite composition. In the case of coal, the determination of moisture, volatile matter, fixed carbon (by difference), and ash.

NOTE.—Sulfur in coal, although commonly reported with the proximate analysis, is not correctly a part thereof, being elementary and of definite composition. Sulfur moreover is distributed, in the proximate analysis, as a constituent of two or more of the ingredients thus determined.

Ultimate Analysis.—The quantitative determination of the elementary constituents. In the case of coal, the determination of carbon, hydrogen, and oxygen (by difference), exclusive of such portions as may be present in the incombustible residue, and the determination of sulfur and nitrogen in the entire material.

NOTE.—Part of the hydrogen and oxygen as determined is present in the moisture of the coal.

Moisture.—That constituent part, largely made up of water, in a substance, which is separated from it in analysis under specified conditions of drying. In the case of coal, the loss incurred by heating at 105° C. in accordance with the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) of the American Society for Testing Materials.[2] As occurring in coal, moisture may or may not be apparent to the eye and touch.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[2] 1921 Book of A.S.T.M. Standards.

Volatile Matter.—In the case of coal, that portion (exclusive of moisture) which is driven off by destructive distillation under the conditions specified in the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) of the American Society for Testing Materials.[1] It is not contained in the coal as such, but is formed by decomposition, and consists of combustible matter (tars and gases) and incombustible matter whose respective proportions vary with the type of coal.

Fixed Carbon.—In the case of coal, the solid residue, other than ash, obtained by destructive distillation under the conditions specified in the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) of the American Society for Testing Materials.[1] It is made up principally of carbon, but contains also appreciable quantities of sulfur, hydrogen, nitrogen and oxygen.

Ash.—Inorganic residue remaining after complete ignition of combustible substances. In the case of coal, the residue after igniting under the conditions specified in the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) of the American Society for Testing Materials.[1]

NOTE.—The ash as thus determined is less in amount than that of the actual incombustible constituents of dry coal owing to chemical changes which occur in these by burning.

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[1] 1921 Book of A.S.T.M. Standards.

TENTATIVE METHODS OF TESTING SMALL CLEAR SPECIMENS OF TIMBER.[1]

Serial Designation: D 143 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Purpose of Tests. 1. Tests on small clear specimens of wood are made to afford:

(*a*) Data for comparing the mechanical properties of various species.

(*b*) Data for the establishment of correct strength functions or working stresses.

(*c*) Data upon which to determine the influence on the mechanical properties of such factors as density, locality of growth, position in cross-section, height of timber in the tree, change of properties with seasoning, and change from sapwood to heartwood.

Kind of Tests. 2. The principal tests used to determine the mechanical properties are static bending, compression parallel to grain, impact bending, compression perpendicular to grain, hardness, shear parallel to grain, tension perpendicular to grain, cleavage, and tension parallel to grain. The principal physical properties which will be determined are specific gravity, radial shrinkage, tangential shrinkage, and shrinkage in volume.

MATERIAL.

I. COLLECTION.

(*A*) *Selection.*

Authentic Identification. 3. The material shall be from trees selected in the forest by one qualified to indentify the species.

Selection and Number of Trees. 4. For each species to be tested from a given locality, at least five representative trees of merchantable size and of approximately average age shall be selected.

Selection and Number of Bolts. 5. The material from five trees of each species from a given locality shall be selected as follows:

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, Forest Products Laboratory, Madison, Wis.

(*a*) From one tree, the entire merchantable bole, if not over 16 ft. in length;[1] if over 16 ft. in length, four 4-ft. sections or bolts, the first to be taken at the stump, the second and third at distances of one-eighth and three-eighths, respectively, of the merchantable length above the stump or as near thereto as possible; and the fourth at the top of the merchantable length.

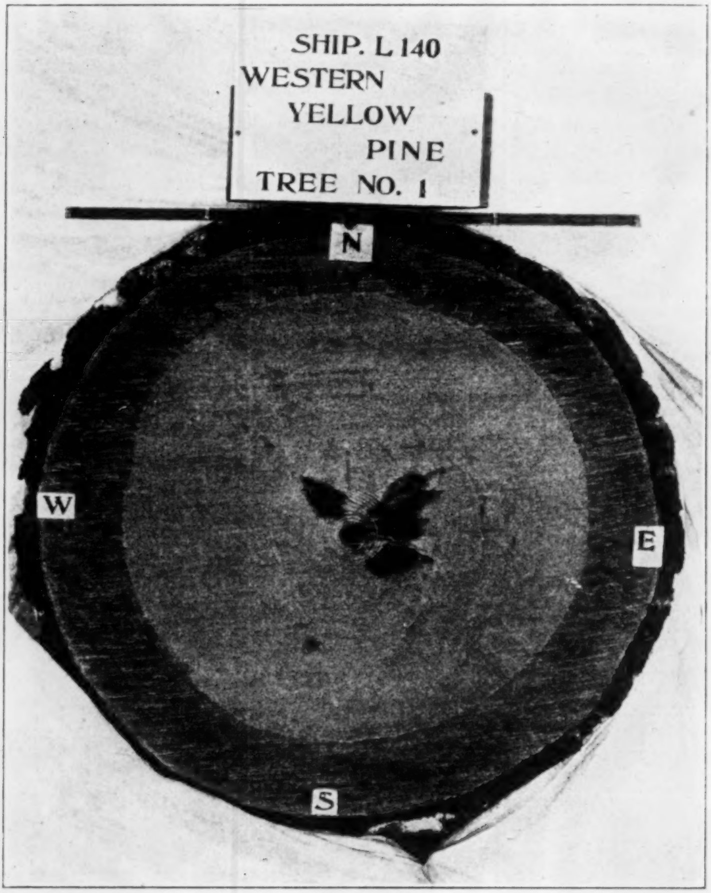

FIG. 1.—Section of Log Selected for Test Material.

(*b*) From two trees, the 8-ft. section next above the 8-ft. butt log.

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[1] Experience has shown that four sections or bolts, each 4 ft. in length, will usually be sufficient for studying the influence of height in tree on the mechanical properties.

(*c*) From two trees, the 4-ft. section next above the 12-ft. butt log.

Substitution of Flitches for Bolts.

6. In cases where the logs or bolts are over 36 in. in diameter, a single flitch 6 in. in thickness, taken through the pith in a north and south direction and representing the full diameter of the log, may be substituted, in the same length, for the full log or bolt specified fn Section 5.

Selection from Small Trees.

7. When the trees are relatively small in diameter, material in addition to that provided for in Sections 5 and 6 shall be collected, whenever possible, to insure a sufficient number of tests to give a good average for the species.

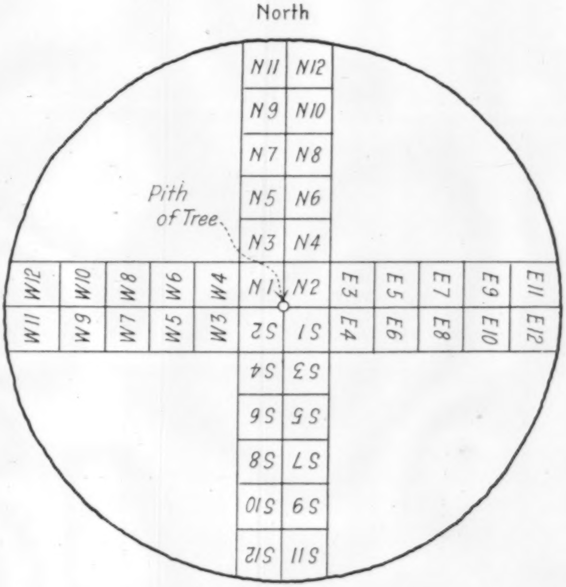

FIG. 2.—Sketch Showing Method of Cutting up the Bolt and Marking the Sticks.

(*B*) *Field Marking.*

Tree Designation.

8. Each tree shall be given an arabic number, the numbering in any given shipment to be consecutive for trees of a given species.

Bolt Designation.

9. Each 4 ft. of length of a tree or log shall be considered a "bolt." Bolts shall be designated by small letters, beginning with *a* for the 4-ft. section next above the stump. Bolt letters, therefore, indicate position with respect to height in tree.

Manner of Marking.

10. The tree number and bolt designation shall be plainly marked upon each log selected by the collector. Thus the 16-ft. butt log of

Tree No. 2 would be designated *2abcd*. Steel dies are recommended for marking the butt end of the logs.

Cardinal Point Indicated.

11. The north side of each log shall be indicated in some convenient manner.

Shipment Number.

12. All material collected from a given locality and shipped at one time shall be given a shipment number or other designation.

TABLE I.—SHIPMENT DESCRIPTION FIELD NOTES.

Project No., *124* Shipment No., *323*
Tree No., *10* Species, *Lodgepole pine*
Locality cut: State, *Montana* County, *Jefferson*
Township, *6 N., R. 7 W., M. P. M.* Date cut, *Oct. 10, 1914*
Slope, *Moderate* Absolute elevation, *6600 ft.* Aspect, *southeasterly*
Undergrowth, *None* Soil, *Deep, fresh-decomposed granite*
Height, *73.9 ft.* Seedling or sprout, *Seedling* Age, *140*
Crown, *Length 25 ft., width 12 ft.* D.B.H. *11.1 in.*
Stem, *Sound, smooth, clear, length 20 ft.* Date sawed, *Oct. 10, 1914*
How and when transported from woods, *By sleigh and wagon, Oct. 13 to 15, 1914.*

LIST OF SPECIMENS SAWED.

Log No.	Bolts.	Length, ft.	Diameter Inside Bark.		Volume.	Feetage, b. m.	Weight, Oct. 15, lb.
			Butt, in.	Top, in.			
1	bcd	12.1	11	9.6	..	..	336
2	efg	12.1	9.6	8.9	..	..	289
3	hij	12.1	8.9	7.7	..	..	242
4	klm	12.1	7.7	6.1	..	..	176
5	nop	12.1	6.1	3.1	..	..	95

REMARKS: *Stump height, 1.0 ft. Butt off on account of frost crack 3.0 ft. Length of top above last section taken, 9.4 ft. Total age, 140 years. Tree was dominant throughout life. Rate of growth, regular and good average for Site I. Lower slope type, although of more than average height for the age and diameter found on poorer sites.*

(*C*) *Field Descriptions.*

Field Descriptions.

13. (*a*) Complete field notes describing the material shall be fully and carefully made by the collector. These notes shall in general, supply data as outlined in Table I.

(*b*) Photographs of the standing trees selected shall be taken.

(*D*) *Preparation for Shipment.*

Preparation for Shipment.

14. (*a*) The bark will be left on each log, and care shall be taken to keep the bark intact. The ends of the logs shall be carefully painted to retard or prevent end drying and end checking.

(*b*) Record shall be made of the shipment routing, bill of lading, kind of shipment, date of shipment, and condition of material when shipped.

(*c*) Record shall also be made of date of receipt of shipment at destination, its condition and method of storage.

II. DISPOSITION.

(*A*) *Storage of Logs at Destination.*

Storage of Logs.

15. Material shall not be kept in the bolt or log form long enough to permit damage by checks, decay, stains, or insect attack. The logs shall be piled on skids, free from contact with the soil, and shall not be stored where subjected to artificial heat. In addition they should preferably be protected from the sun.

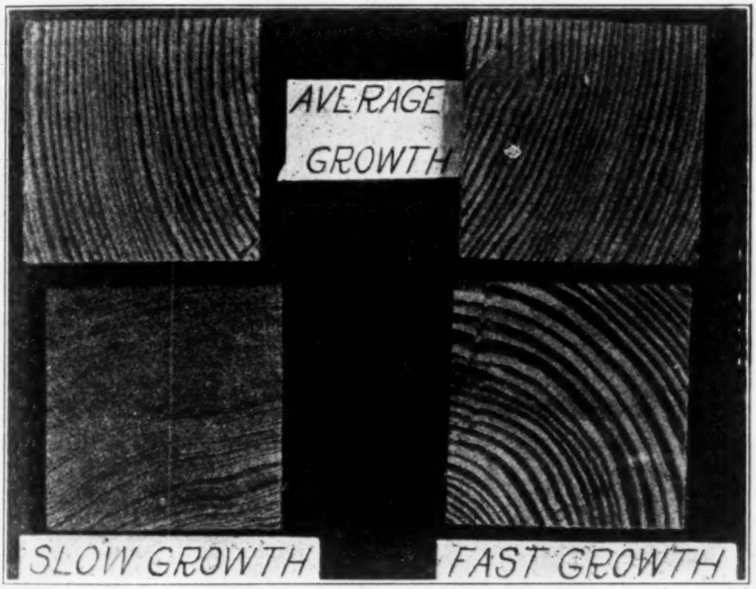

FIG. 3.—Cross-Sections of Bending Specimens Showing Different Rates of Growth of Longleaf Pine (2 by 2-in. Specimens).

B) *Photographing, Sawing and Final Marking.*

Photographing Ends of Bolts.

16. The top end of each *d* or *c-d* bolt shall be photographed. It is suggested that a rule be so placed on the log as to indicate the scale of the photograph and that the cardinal points be indicated on the cross-section. Fig. 1 shows a photograph of this kind.

Sawing of Bolts.

17. (*a*) All bolts shall be marked on the top end into $2\frac{1}{2}$ by $2\frac{1}{2}$-in. squares as shown in Fig. 2, and sawed into nominal $2\frac{1}{2}$ by $2\frac{1}{2}$-in. sticks. The letters *N*, *E*, *S*, and *W* indicate the cardinal points.

(*b*) When flitches are substituted for bolts (Section 6), the same general marking and numbering scheme of Paragraph (*a*) shall be followed in so far as it is applicable.

Marking of Test Sticks.

18. All test sticks shall bear the shipment number, the tree number, stick number, and bolt designation, to be known respectively as Shipment No., Piece No., Stick No., and mark. Thus 400-1-*N*4*d* represents Stick *N*4 of Bolt *d*, Tree 1, Shipment 400.

(*C*) *Matching for Air-dry Tests.*

Composition Bolts.

19. In the tests made to determine the effect of air-drying on strength, the sticks from the *c* bolt shall be interchanged with those of the *d* bolt of the same tree to form two composition bolts, each composition bolt being complete and being made of equal portions of *c* and *d* bolts. The sticks from one of these composition bolts shall be tested green and those from the other shall be tested after air drying. The sticks tested either green or air dry shall be regarded as if they were from the same bolt.

Schedule for Forming Composition Bolts.

20. The division of green and air-dry sticks shall be made according to the following schedule in which the numbers refer to stick numbers:

Composition Bolt to be Tested Green.—

Lower bolt *c*....................	1		4, 5		8, 9	
Upper bolt *d*.......................		2, 3		6, 7		10, etc

Composition Bolt to be Air Dried and Tested.—

Lower bolt *c*.......................		2, 3		6, 7		10, etc.
Upper bolt *d*....................	1		4, 5		8, 9	

(*D*) *Disposition of Sticks.*

Green Material.

21. The sticks ($2\frac{1}{2}$ by $2\frac{1}{2}$ in. by 4 ft.) to be tested green shall be kept in an unseasoned condition while awaiting preparation for test by being stored in a framed pit or other suitable container, where they shall be close piled and covered with damp sawdust or in some other suitable manner. As material is required for test, it shall be removed from this pit, or container, surfaced on all four sides to 2-in. by 2-in. in cross-section, sawed to test size and kept covered with a damp cloth, in an air-tight container at a temperature of about 70° F. (as nearly as practicable) until the time of test. Care shall be taken to avoid as much as possible the storage of green material in any form. Sticks to be tested in a green condition should usually not be sawed from the log form in quantities greater than is required to meet the

testing demands for from a few days to not more than two weeks, depending on the prevailing conditions.

Air-dry Material.

22. (*a*) The ends of the sticks to be air dried ($2\frac{1}{2}$ by $2\frac{1}{2}$ in. by 4 ft.) shall be dipped in melted paraffin or other substance suitable to retard checking. The material shall be piled so as to have a space of at least $\frac{1}{2}$ in. on each side of each stick to permit circulation of air. The material shall be stored in a place allowing free access of air, but protected from sunshine, rain, snow, and moisture from the ground. The sticks in drying shall not be subjected to artificial heat.

(*b*) All of the sticks from each composite bolt to be air dried shall be weighed when stored and at sufficiently frequent intervals thereafter to get accurate data on the progress of seasoning. No material shall be considered thoroughly air dried and properly conditioned for testing until practically constant weight has been reached. (Wood absorbs and gives off moisture with changing atmospheric conditions, consequently it never comes to absolutely constant weight.)

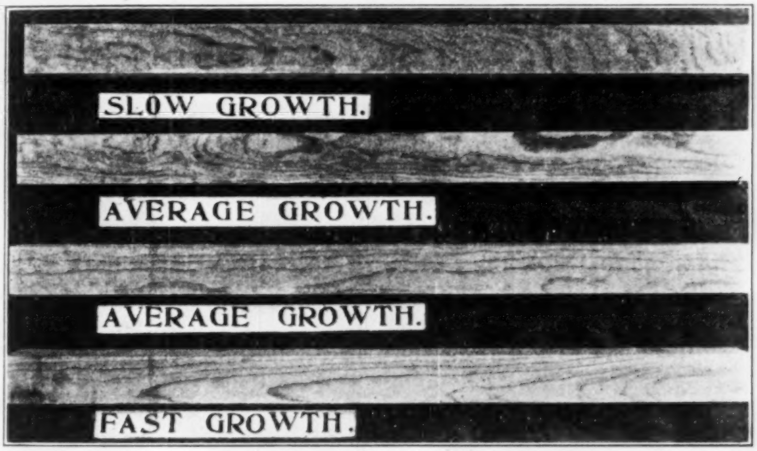

FIG. 4.—Tangential Surfaces of Bending Specimens of Different Rates of Growth of Jeffrey Pine (2 by 2 by 30-in. Specimens).

(*c*) When the material has reached equilibrium, moisture sections 1 in. in length shall be taken from about 10 per cent of the sticks to determine the actual moisture content. These moisture specimens shall be cut not less than 1 ft. from the ends of the sticks, and in such a way as to prevent any appreciable loss of material for testing. When thoroughly air dry, the material shall be surfaced on four sides to 2 in. by 2 in. in cross-section and tested.

TESTING.

III. ORDER, SELECTION, AND NUMBER.

(*A*) *Order.*

Order of Tests.

23. The order of tests in all cases shall be such as to eliminate as far as possible from the comparisons the effect of changes in the specimen due to such factors as storage and weather conditions.

(*B*) *Selection.*

Preference in Selecting Specimens.

24. In case the material from a given bolt should be insufficient to furnish all the test specimens hereinafter required, the preferential order of mechanical tests to be used in selecting specimens shall be as follows: Static bending, compression parallel to grain, impact bending, compression perpendicular to grain, hardness, shear parallel to grain, tension perpendicular to grain, cleavage, and tension parallel to grain.

Test Pieces from Bending Specimens After Failure.

25. In many cases where a shortage of material exists, certain test specimens may be taken from the uninjured portion of the static and impact bending specimens remaining after test, provided proper care is used in the selection.

Quality of Test Material.

26. Only clear straight-grained material, free from decay and other defects, shall be used for the tests. However, small knots and other similar defects may be admitted in such specimens as static bending when their location is such that it is certain they will not in any way influence the failure or otherwise affect the strength of the specimen.

(*C*) *Number of Tests for Each Bolt.*

Static Bending.

27. One static bending specimen shall be taken from each pair of sticks. A pair consists of two adjacent sticks equi-distant from the pith, as *W*3 and *W*4, Fig. 2. In the composite bolts tested to afford a comparison of the strength of green and air-dry material, the pair of sticks shall be constituted as above, except that the sticks in this case will be from different bolts. Thus *W3d* and *W4c* constitute one pair of sticks to be tested green, and *W3c* and *W4d* the corresponding pair to be tested air dry (Section 20).

Compression Parallel to Grain.

28. One compression-parallel-to-grain specimen shall be taken from each stick. Load-compression curves shall be taken on 20 per cent of the specimens.

Impact Bending.

29. Eight impact-bending specimens shall be taken from each bolt, selection being made from the sticks remaining after obtaining the static bending tests. Two of the specimens shall be selected from

near the pith, two from near the periphery, and four which are representative of the cross-section.

Compression Perpendicular to Grain. 30. One compression-perpendicular-to-grain specimen shall be taken from each of 50 per cent of the sticks selected for static bending.

Hardness. 31. One hardness specimen shall be taken from each of the other 50 per cent of the static-bending sticks.

Shear Parallel to Grain. 32. Eight shear-parallel-to-grain specimens shall be selected from the unused portion or ends of four sticks from which bending specimens have been selected. Two specimens shall be taken from near the pith, two from near the periphery, and four that are representative of the average growth of the cross-section of the bolt. One of each pair of specimens from the same stick shall be tested in radial shear (surface of failure radial) and the other in tangential shear (surface of failure tangential).

Tension Perpendi to Grain. 33. Eight tension-perpendicular-to-grain specimens shall be selected from four sticks in a manner similar to that for shear (Section 32). One of each pair of specimens from the same stick shall be tested in radial tension (surface of failure radial) and the other in tangential tension (surface of failure tangential).

Cleavage Perpendicular to Grain. 34. Eight cleavage specimens shall be selected from four sticks in a manner similar to that for shear (Section 32). One of each pair of specimens from the same stick shall be tested in radial cleavage (surface of failure radial) and the other in tangential cleavage (surface of failure tangential).

Tension Parallel to Grain. 35. Four tension-parallel-to-grain specimens shall be chosen of which one shall be selected from near the pith, one from near the periphery, and two which are representative of the cross-section.

Specific Gravity and Shrinkage in Volume. 36. Six specific gravity and shrinkage-in-volume specimens shall be selected from the unused portion of bending or tension-parallel-to-grain sticks, selected so as to give one from near the pith, one from near the periphery, and four that are representative of the average growth of the cross-section of the bolt. These specimens shall be selected only from the sticks to be tested in a green condition.

Radial Shrinkage. 37. Two radial shrinkage specimens shall be obtained from each *d* bolt. They shall be cut from the "sectors" or "quadrants" remaining after sawing (Fig. 2) or from disks cut from near the end of the bolt. When a disk is used, care must be taken to see that it is green, and has not been affected by shrinking and checking which is common near the end of the bolt. The specimens shall not be surfaced. Radial shrinkage specimens shall be cut with their width in the radial direction. One shall be taken from the heartwood, and the other from near the periphery. When possible, the second shall consist entirely of sapwood.

Tangential Shrinkage.

38. Two tangential shrinkage specimens shall be obtained from each *d* bolt. They shall be selected at the same time and in a manner similar to radial-shrinkage specimens (Section 37), except the width shall be in a tangential direction. The specimens shall not be surfaced. One shall be taken from the heartwood, the other from near the periphery and when possible shall consist entirely of sapwood. The heartwood and the sapwood specimens shall be taken adjacent to the respective specimens selected for radial shrinkage.

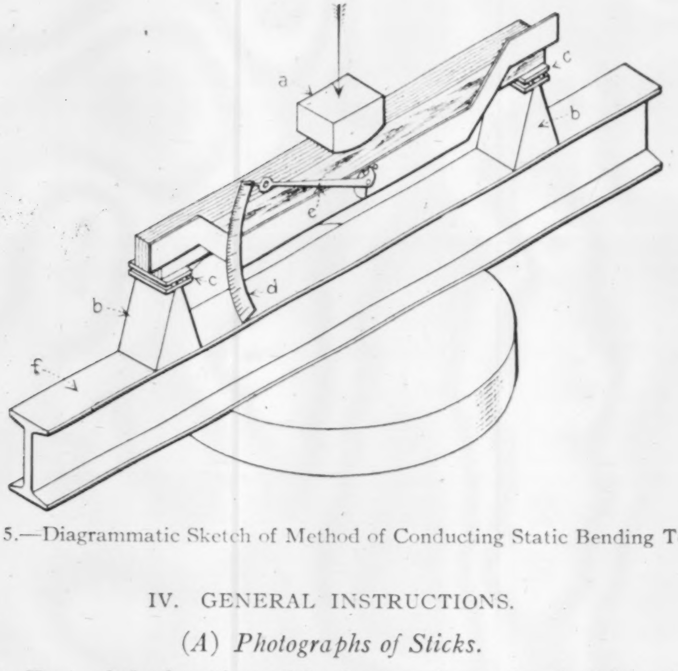

Fig. 5.—Diagrammatic Sketch of Method of Conducting Static Bending Test.

IV. GENERAL INSTRUCTIONS.

(*A*) *Photographs of Sticks.*

Sticks to be Photographed.

39. Four of the bending sticks from each species shall be selected for photographing, as follows: 2 average growth, 1 fast growth, and 1 slow growth. These sticks shall be photographed in cross-section and on the radial and tangential surfaces. Fig. 3 is a typical photograph of the cross-section of test specimens and Fig. 4 of the tangential surface of bending specimens.

(*B*) *Control of Moisture Content.*

Control of Moisture Content.

40. As previously specified (Section 22) sticks for test in the air-dry condition shall be brought to practically constant weight

before test. Tests shall then be carried out in such a manner that large changes in moisture content will not occur. (For instance, in ordinary heated rooms the relative humidity is usually below 30 per cent. If wood which has been dried to practically constant weight under the condition specified by Section 22 is brought into such a room, a considerable and rather rapid drying out will occur.) To prevent such changes, the testing room and rooms for the preparation of test specimens should preferably have some means of humidity control.

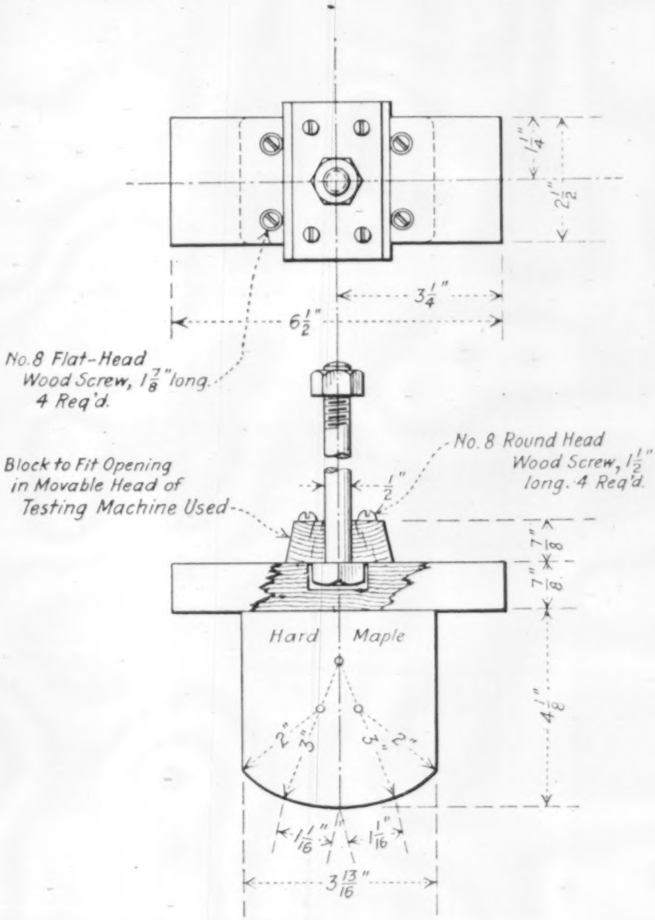
1/4"
2 1/2"
3 1/4"
6 1/2"
No. 8 Flat-Head Wood Screw, 1 7/8" long. 4 Req'd.
Block to Fit Opening in Movable Head of Testing Machine Used
No. 8 Round Head Wood Screw, 1 1/2" long. 4 Req'd.
1/2"
7/8"
7/8"
Hard Maple
4 1/8"
2"
3"
3"
2"
1 1/16"
1 1/16"
3 13/16"

FIG. 6.—Details of Bearing Block for Bending Tests.

(*C*) *Record of Heartwood and Sapwood.*

Proportion of Sapwood.

41. The estimated proportion of sapwood present shall be recorded for each test specimen.

V. PROCEDURE.

(*A*) *Static Bending.*

Size of Specimens.

42. The static bending tests shall be made on nominal 2 by 2 by 30-in. specimens. The actual height and width at the center, and the length shall be measured.

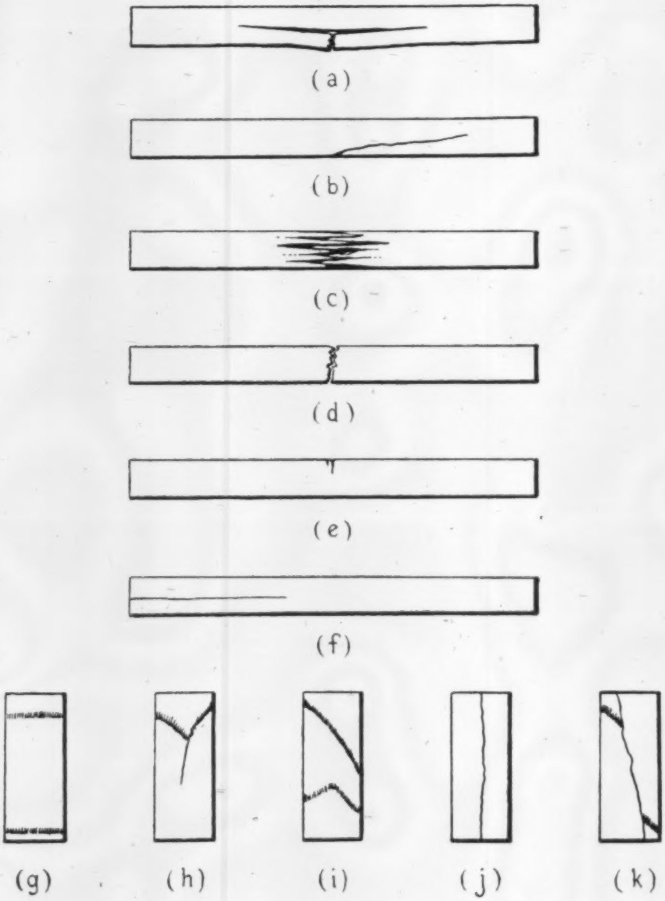

FIG. 7.—Types of Failures: *a* to *f*, Bending; *g* to *k*, Compression Parallel to Grain.

Loading Span and Supports.

43. Center loading and a span length of 28 in. shall be used. Both supporting knife edges shall be provided with bearing plates and rollers having a total thickness of approximately $1\frac{1}{4}$ in. in order to

bring the neutral plane of the test specimen about $2\frac{1}{4}$ in. from the knife edges (Fig. 5.)

Bearing Block. 44. A bearing block of the form and size of that shown in Fig. 6 shall be used for applying the load.

Placement of Growth Rings. 45. The specimen shall be placed so that the load will be applied through the bearing block to the tangential (flat-sawn) surface nearest the pith.

Rate of Application of Load. 46. The load shall be applied continuously throughout the test at a rate of 0.10 in. per minute.

Load-Deflection Curves. 47. (*a*) Load-deflection curves shall be taken to or beyond the maximum load for all static bending tests. In one-third of the tests, the curves shall be continued to a 6-in. deflection, or until the specimen fails to support a load of 200 lb.

(*b*) Deflections of the neutral plane at the center of the length shall be taken with respect to points in the neutral plane above the supports.

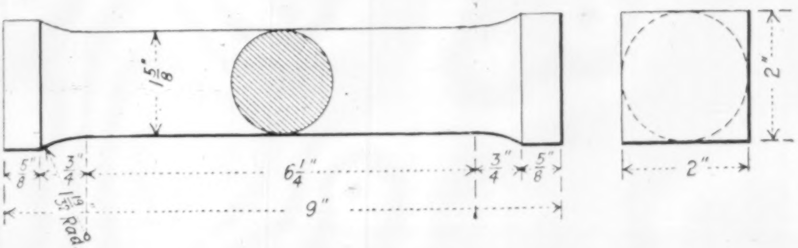

FIG. 8.—Compression-Parallel-to-Grain Test Specimen Special Form.

(*c*) Within the elastic limit, deflection readings shall be taken to 0.0025 in. After the elastic limit has been reached, less refinement is necessary in observing deflections, and these may then be read directly to the nearest 0.01 in. by means of a wire stretched across a scale. Fig. 5 illustrates the method of test and type of deflectiometer recommended for deflections up to 1 in.

(*d*) The load and deflection of first failure, the maximum load, and points of sudden change shall be shown on the curve sheet[1] although they may not occur at one of the regular load or deflection increments.

Description of Failures. 48. Bending failures shall be classified according to the appearance of the fractured surface and according to the manner in which the failure develops. The fractured surfaces may be roughly divided into brash and fibrous, the term "brash" indicating an abrupt failure and the term "fibrous" indicating a fracture showing splinters. The test failures shall be classified and described as follows:

---

[1] See Fig. 1 of the Appendix for a sample static bending data sheet form. Fig. 2 of the Appendix shows a sample computation data card.

Simple tension (see Fig. 7*a*);
Cross grain[1] tension (see Fig. 7*b*);

> The presence of cross grain having a slope which deviates more than 1 in 20 from the longitudinal edges of the specimen shall be cause for culling the test.

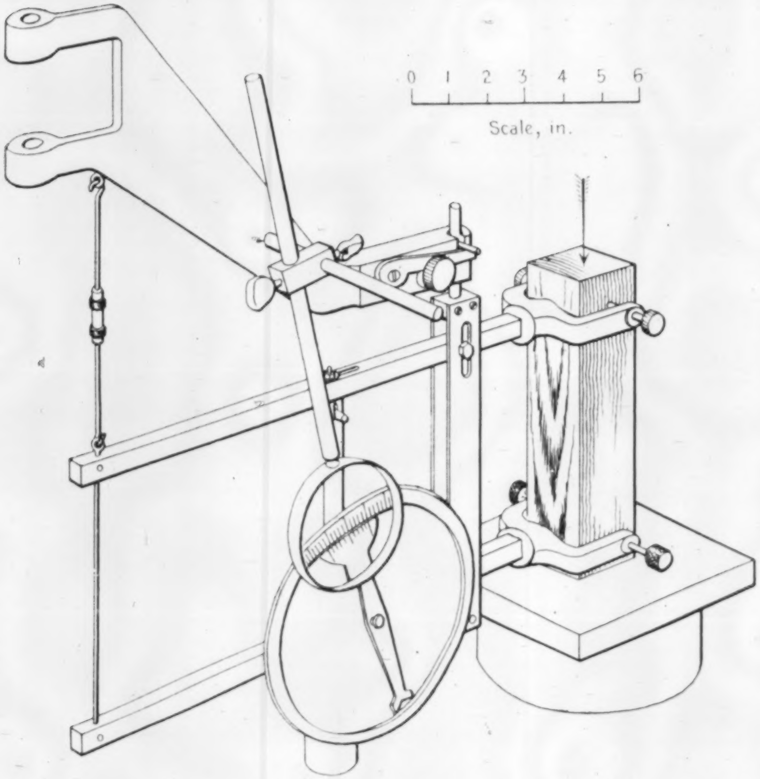

FIG. 9.—Diagrammatic Sketch of U. S. Forest Service Compressometer and Method of Conducting Compression-Parallel-to-Grain Test.

Splintering tension (see Fig. 7*c*);
Brash tension (see Fig. 7*d*);
Compression (see Fig. 7*e*);
Horizontal shear (see Fig. 7*f*).

---

[1] The term "cross grain" shall be considered to include all deviations of grain from the direction of the longitudinal axis or longitudinal edges of the specimen. It should be noted that spiral grain may be present even to a serious extent without being evident from a casual observation.

In case two or more kinds of failures develop, all shall be described in the order of their occurrence; thus, compression followed by splintering tension. The failure shall be sketched on the data sheet.

Weight and Moisture Content.

49. The specimen shall be weighed after test and a moisture section 1 in. in length shall be cut near the failure.

(*B*) *Compression Parallel to Grain.*

Size of Specimens.

50. The compression-parallel-to-grain tests shall be made (1) on nominal 2 by 2 by 8-in. specimens, or (2) on specimens of the special form shown in Fig. 8. The actual cross-section dimensions, or the diameter at minimum section, and the length shall be measured.

Advantage of Special Form.

51. The specimen with reduced cross-section (Fig. 8) will usually require less care preparatory to test in order to prevent crushing at the ends than the specimen with uniform cross-section throughout the length.

End Surfaces Parallel.

52. Care shall be used in preparing the compression-parallel-to-grain test specimens to make the end surfaces parallel.

Spherical Bearing.

53. A spherical bearing block shall be used and so adjusted for each test as to obtain a uniform distribution of load over the ends of the specimen.

Rate of Application of Load.

54. The load shall be applied continuously throughout the test at a rate of 0.024 in. per minute.

Load Compression Curves.

55. (*a*) Load-compression curves shall be taken for a 6-in. central gage length on 20 per cent of the specimens. Load-compression readings shall be continued until the elastic limit is well passed, as indicated by the curve.[1] On the other 80 per cent of the specimens the maximum load only will be obtained.

(*b*) Deformations shall be read to 0.0005 in.

(*c*) Fig. 9 illustrates a type of compressometer, using a Johnson dial, which has been found satisfactory for wood testing.

Position of Test Failures.

56. In order to obtain satisfactory and uniform results, it is necessary that the failures be made to develop in the body of the specimen. With specimens of uniform cross-section, this result can best be obtained when the ends are at a very slightly lower moisture content than the body. With green material it will usually suffice to close-pile the specimens, cover the body with a damp or wet cloth and expose the ends for a short time. For air-dry material, it may sometimes be advisable to pile the specimens in a similar manner and place them in a desiccator should the failures in test indicate that a slight end drying is necessary.

---

[1] See Fig. 4 of the Appendix for a sample compression-parallel-to-grain data sheet form. Fig. 3 of the Appendix shows a sample computation data card.

Description of Failures.

57. Compression failures shall be classified and described according to their appearance, as follows:

(*a*) *Crushing.*—This term shall be used when the plane of rupture is approximately horizontal. See Fig. 7(*g*).

(*b*) *Wedge Split.*—The direction of the split, that is whether radial or tangential, should be noted. See Fig. 7(*h*).

(*c*) *Shearing.*—This term shall be used when the plane of rupture makes an acute angle with the axis of the specimen. See Fig. 7(*i*).

(*d*) *Splitting.*—See Fig. 7(*j*).

(*e*) *Compression and Shearing Parallel to Grain.*—This failure usually occurs in cross-grained pieces, and should be culled as a compression test. See Fig. 7(*k*). The failure shall be sketched on the data sheet. In addition the location of the failure shall be recorded along with its description.

Weight and Moisture Content.

58. The specimen shall be weighed after test and a moisture section 1 in. in length shall be cut from the body near the failure.

Ring and Summer Wood Measurement.

59. After the moisture section has been weighed, the number of rings per inch and the proportion of summer wood shall be measured over a representative inch of cross-section. In determining the proportion of summer wood, it is essential that the end surface be prepared so as to permit accurate summer wood measurement. When the fibers are broomed over at the ends from sawing, a light sanding, planing, or similar treatment of the ends is recommended.

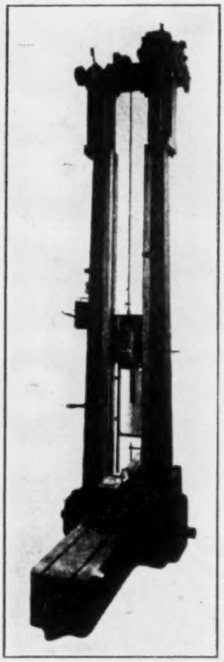

FIG. 10.—Hatt-Turner Impact Machine, Illustrating Method of Conducting Impact Bending Test.

(C) *Impact Bending.*

Size of Specimens.

60. The impact bending tests shall be made on nominal 2 by 2 by 30-in. specimens. The actual height and width at the center and the length shall be measured.

Loading and Span.

61. Center loading and a span length of 28 in. shall be used.

Bearing Block.

62. A metal tup of curvature corresponding to the bearing block shown in Fig. 6 shall be used in applying the load.

Placement of Growth Rings.

63. The specimen shall be placed so that the load will be applied through the bearing block to the tangential or flat-sawn surface nearest the pith.

Method of Test. 64. The tests shall be made by increment drops in a Hatt-Turner impact or similar machine. See Fig. 10. The first drop shall be 1 in., which shall be increased by 1-in. increments until a height of 10 in. is reached. A 2-in. increment shall then be used until complete failure occurs or until a 6-in. deflection is reached.

Weight of Hammer. 65. A 50-lb. hammer shall be used when, with drops up to the capacity of the machine (about 68 in. for the small Hatt-Turner impact machine), it is practically certain that complete failure or a 6-in. deflection will result for all specimens of a species. For all other cases a 100-lb. hammer shall be used.

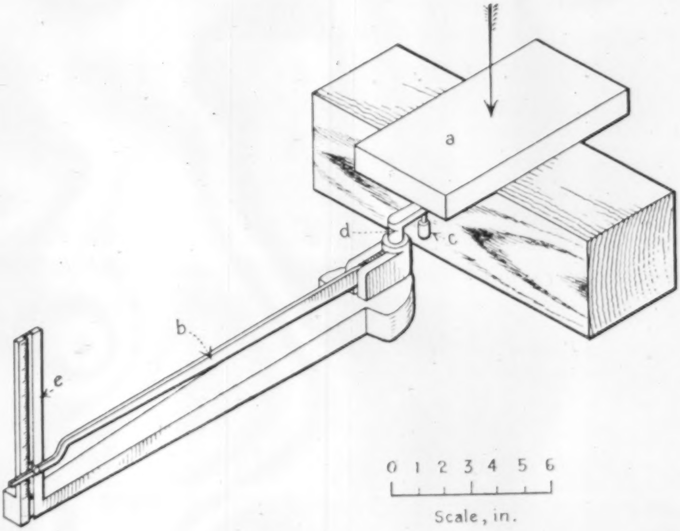

FIG. 11.—Diagrammatic Sketch of Method of Conducting Compression-Perpendicular-to-Grain Test.

Deflection Records. 66. Graphical drum records,[1] giving the deflection for each drop and the set, if any, shall be made until first failure occurs. This record shall also afford data from which the exact height of drop can be scaled for at least the first four falls.

Drop Causing Failure. 67. The height of drop causing complete failure, or a 6-in. deflection, shall be observed for each specimen.

Description of Failure. 68. The failure shall be sketched on the data sheet[2] and described in accordance with the directions for static bending under Section 48.

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[1] See Fig. 5 of the Appendix for a sample drum record.

[2] See Fig. 7 of the Appendix for a sample impact bending data sheet form. Fig. 6 of the Appendix shows a sample computation data card.

Weight and Moisture Content. 69. The specimen shall be weighed after the test and a moisture section 1 in. in length shall be cut near the failure.

(*D*) *Compression Perpendicular to Grain.*

Size of Specimens. 70. The compression-perpendicular-to-grain tests shall be made on nominal 2 by 2 by 6-in. specimens. The actual height, width, and length shall be measured.

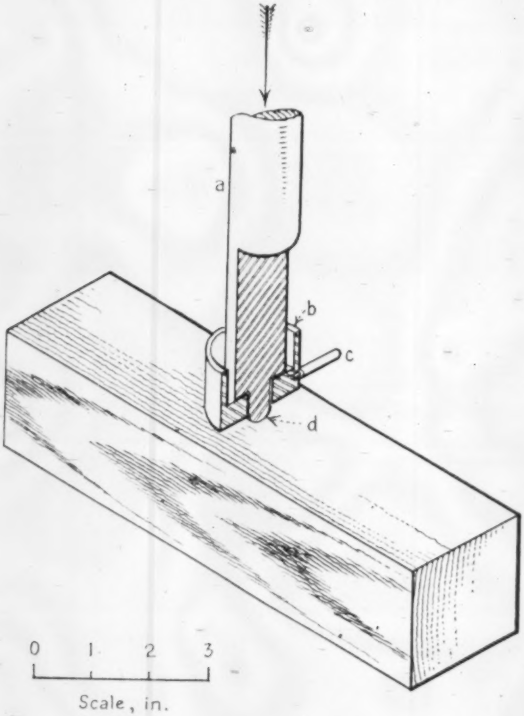

FIG. 12.—Diagrammatic Sketch of Method of Conducting Hardness Test.

Loading. 71. The load shall be applied through a metal bearing plate 2 in. in width, placed across the upper surface of the specimen at equal distances from the ends and at right angles to the length. (See Fig. 11.)

Placement of Growth Rings. 72. The specimen shall be placed so that the load will be applied through the bearing plate to a radial (quarter-sawn) surface.

Rate of Application of Load. 73. The load shall be applied continuously throughout the test at a rate of 0.024 in. per minute.

74. (*a*) Load-compression curves[1] shall be taken for all specimens up to 0.1-in. compression, after which the test will be discontinued. **Load-Compression Curves.**

(*b*) Deflection readings shall be taken to 0.001 in.

75. The specimen shall be weighed after test and a moisture section 1 in. in length shall be cut adjacent to the part under load. **Weight and Moisture Content.**

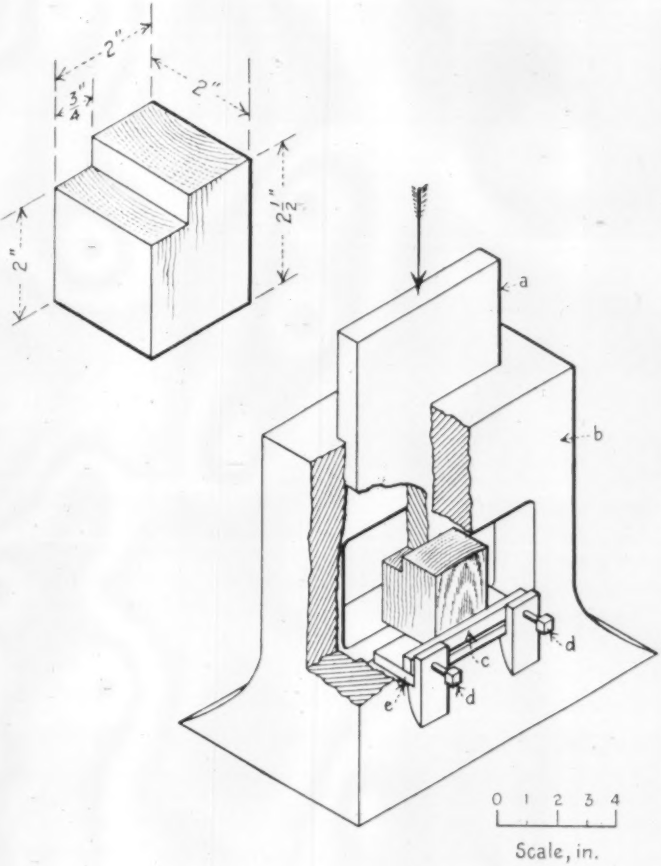

FIG. 13.—Diagrammatic Sketch of Method of Conducting Shear-Parallel-to-Grain Test, with Details of Test Specimen.

(*E*) *Hardness.*

76. The hardness tests shall be made on nominal 2 by 2 by 6-in. specimens. The actual cross-section dimensions and length shall be measured. **Size of Specimens.**

---

[1] See Fig. 8 of the Appendix for a sample compression-perpendicular-to-grain data sheet form. Fig. 9 of the Appendix shows a sample computation data card.

Method of Test. 77. The modified ball test with a "ball" 0.444 in. in diameter shall be used for determining hardness. (See Fig. 12.) The load at which the "ball" has penetrated to one-half its diameter as indicated by the tightening of the collar against the specimen, shall be observed.

Number of Penetrations. 78. Two penetrations shall be made on a tangential surface, two on a radial surface, and two on each end. The choice between the two radial and between the two tangential surfaces shall be such as to give a fair average of the piece. The penetrations shall be far enough from the edge to prevent splitting or chipping.[1]

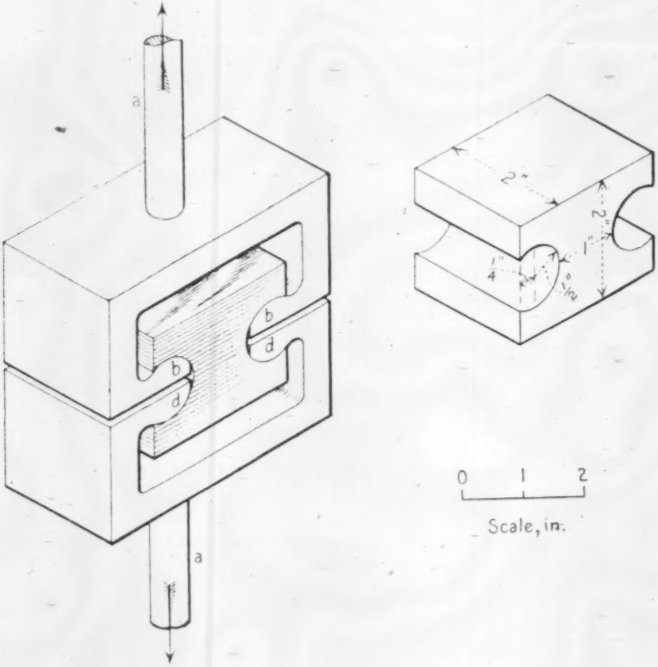

FIG. 14.—Diagrammatic Sketch of Method of Conducting Tension-Perpendicular-to-Grain Test, with Details of Test Specimen.

Weight and Moisture Content. 79. The specimen shall be weighed after test and a moisture section 1 in. in length shall be cut.

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[1] See Fig. 10 of the Appendix for a sample data and computation card.

(*F*) *Shear Parallel to Grain.*

Size of Specimens. 80. The shear-parallel-to-grain tests shall be made on nominal 2 by 2 by 2½-in. specimens notched as illustrated in Fig. 13 to produce failure on a 2 by 2-in. surface. The actual dimensions of the shearing surface shall be measured.

Method of Test. 81. A shear tool similar to that illustrated in Fig. 13, providing a ⅛-in. offset between the inner edge of the supporting surface and the plane along which the failure occurs, shall be used. The load shall be applied and the specimen supported on end-grain surfaces. Care shall be taken in placing the specimen in the shear tool to see that the cross bar is adjusted so that the edges of the specimen are vertical and the end rests evenly on the support over the contact area. The maximum load only will be observed.

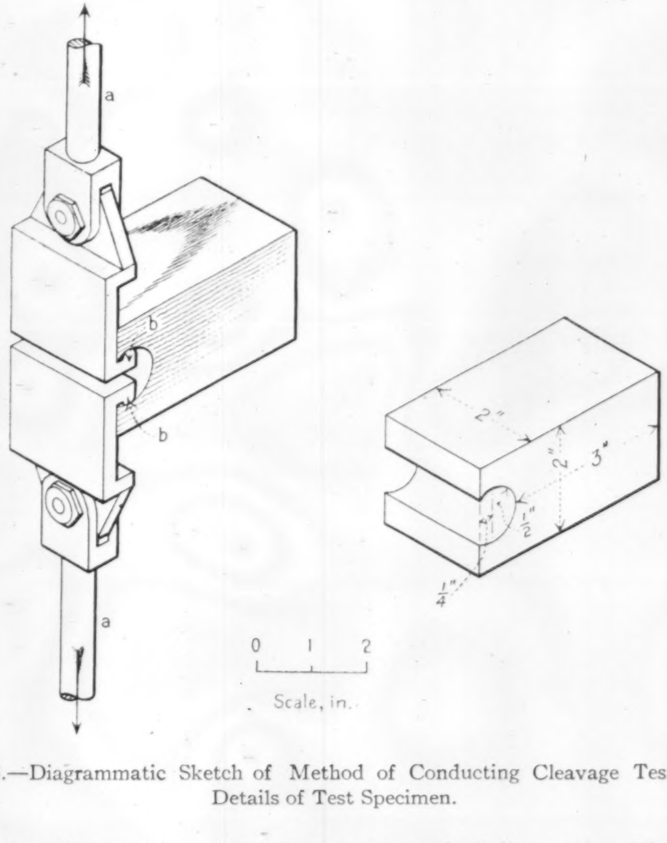


FIG. 15.—Diagrammatic Sketch of Method of Conducting Cleavage Test, with Details of Test Specimen.

Rate of Application of Load.

82. The load shall be applied continuously throughout the test at a rate of 0.015 in. per minute.

Test Failures.

83. The failure shall be sketched on the data card.[1] In all cases where the failure at the base of the specimen extends back onto the supporting surface, the test shall be culled.

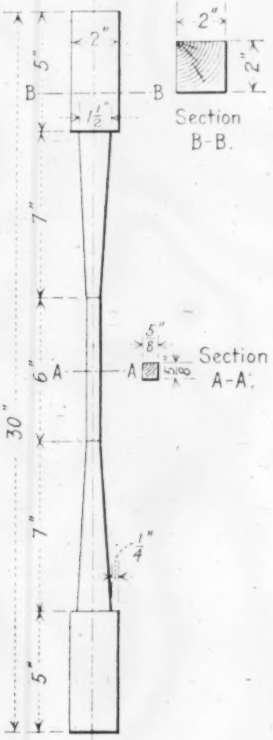


FIG. 16.—Details of Tension-Parallel-to-Grain Test Specimen.

Moisture Content.

84. The portion of the test piece which is sheared off shall be used as a moisture section.

(G) *Tension Perpendicular to Grain.*

Size of Specimens.

85. The tension-perpendicular-to-grain tests shall be made on specimens of the nominal size and shape shown in Fig. 14. The actual width and length at minimum sections shall be measured.

---

[1] See Fig. 11 of the Appendix for a sample tangential-shear data sheet form.

86. The specimens shall be held during test in grips as shown in Fig. 14. The maximum load only shall be observed. **Method of Test.**

87. The load shall be applied continuously throughout the test at a rate of 0.25 in. per minute. **Rate of Application of Load.**

88. The failure shall be sketched on the data card.[1] **Sketch of Failure.**

89. One of the pieces remaining after failure, or a section split along the surface of failure, shall be used as a moisture specimen. **Moisture Content.**

(*H*) *Cleavage.*

90. The cleavage tests shall be made on specimens of the form and size shown in Fig. 15. The actual width and length at minimum section shall be measured. **Size of Specimens.**

91. The specimens shall be held during test in grips as shown in Fig. 15. The maximum load only shall be observed. **Method of Test.**

92. The load shall be applied continuously throughout the test at a rate of 0.25 in. per minute. **Rate of Operation.**

93. The failure shall be sketched on the data card.[2] **Sketch of Failure.**

94. One of the pieces remaining after failure, or a section split along the surface of failure, shall be used as a moisture specimen. **Moisture Content.**

(*I*) *Tension Parallel to Grain.*

95. The tension-parallel-to-grain tests shall be made on specimens of the size and shape shown in Fig. 16. The actual cross-section dimensions at minimum section shall be measured. **Size of Specimens.**

96. The specimen shall be held during test by plates notched to fit around the test piece and under the 0.25-in. shoulder provided for that purpose. A spherical bearing shall be used on at least one end of the specimen. Maximum load only will be observed. **Method of Test.**

97. The load shall be applied continuously throughout the test at a rate of 0.05 in. per minute. **Rate of Application of Load.**

98. The failure shall be sketched on the data sheet.[3] **Sketch of Failure.**

99. A moisture section about 3 in. in length shall be cut from the minimum section near the failure. **Moisture Content.**

(*J*) *Specific Gravity and Shrinkage in Volume.*

100. The specific gravity and shrinkage in volume tests shall be made on nominal 2 by 2 by 6-in. specimens. The actual cross-section dimensions and length shall be measured. **Size of Specimens.**

---

[1] See Fig. 12 of the Appendix for a sample radial-tension-perpendicular-to-grain data sheet form.

[2] See Fig. 13 of the Appendix for a sample radial-cleavage data sheet form.

[3] See Fig. 14 of the Appendix for a sample tension-parallel-to-grain data sheet form.

Determination Method.

101. (*a*) Both specific gravity and shrinkage-in-volume determinations shall be obtained on the same specimen.

(*b*) A carbon impression of the end of the green specimen shall be made on the back of the data card.[1] In like manner, a carbon impression of the same end shall be made after the specimen has been oven dried. (See Paragraph *e*.)

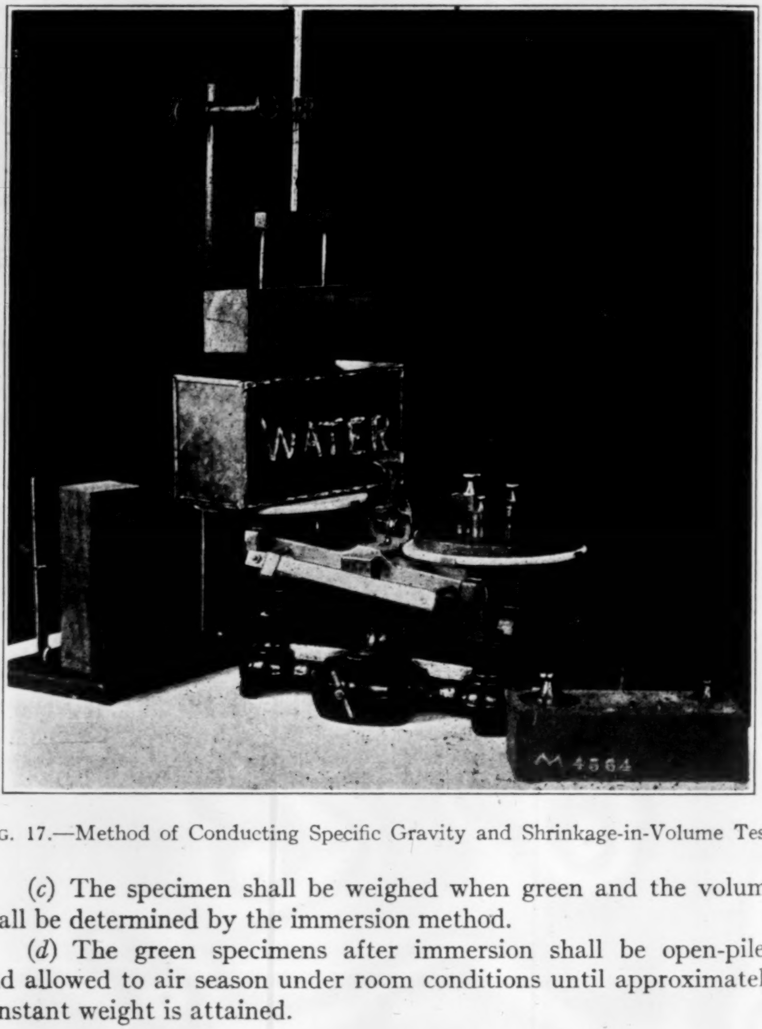


FIG. 17.—Method of Conducting Specific Gravity and Shrinkage-in-Volume Test.

(*c*) The specimen shall be weighed when green and the volume shall be determined by the immersion method.

(*d*) The green specimens after immersion shall be open-piled and allowed to air season under room conditions until approximately constant weight is attained.

---

[1] See Fig. 15 of the Appendix for a sample specific gravity and shrinkage-in-volume data card form.

(*e*) The specimens shall then be open-piled in an oven and dried at 100° C. until constant weight is reached.

(*f*) After oven drying, the specimens shall be weighed, and while still warm shall be immersed in a hot paraffin bath, care being taken to remove them quickly to insure a thin coating.

(*g*) The volume of the paraffin-coated specimen shall be determined by immersion as before.

(*h*) Fig. 17 illustrates the apparatus used in determining the specific gravity and shrinkage in volume.

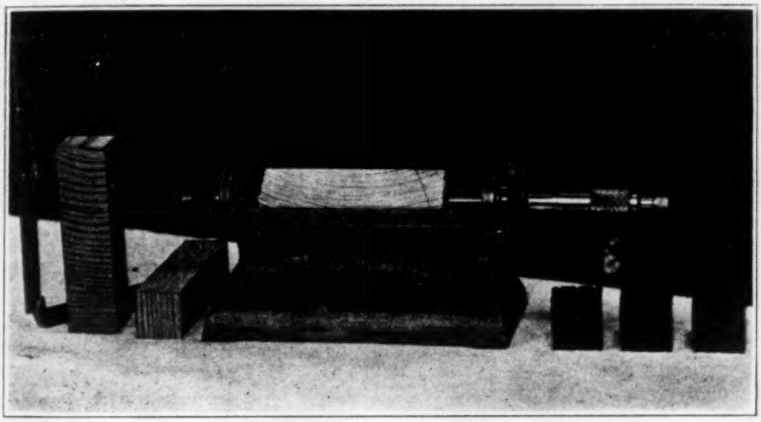


FIG. 18.—Method of Measuring Radial and Tangential Shrinkage.

(*K*) *Radial and Tangential Shrinkage.*

102. The radial and tangential-shrinkage determinations shall be made on nominal 1 by 4 by 1-in. specimens. The specimen shall be measured across the (4-in.) dimension in which the shrinkage is to be determined. **Size of Specimen.**

103. The specimen shall be weighed when green and after subsequent oven drying. **Weight.**

104. (*a*) The green specimens shall be open-piled and allowed to air season under room conditions until approximately constant weight is attained. **Drying.**

(*b*) The specimens shall then be open-piled in an oven and dried at 100° C. until constant weight is attained.

105. Final measurement shall be made on the oven-dry specimen.[1] **Final Measurement.**

---

[1] See Fig. 16 of the Appendix for a sample radial and tangential-shrinkage data card form.

106. Fig. 18 illustrates the method of making the radial and tangential-shrinkage measurements. An ordinary micrometer of required accuracy is suitable for this work.

(*L*) *Moisture Determination.*

Selection. 107. The sample for moisture determinations of each test specimen shall be selected as heretofore described for each test.

Weighing. 108. Immediately after obtaining the moisture sample, all loose splinters shall be removed and the sample shall be weighed.

Drying. 109. The moisture samples shall be open-piled in an oven and dried at a temperature of 100° C. until constant weight is attained, after which the oven-dry weight shall be determined.

Moisture Content. 110. The loss in weight expressed in percentage of the oven-dry weight as above determined shall be considered the moisture content of the specimen.

VI. TOLERANCES.

(*A*) *Weights.*

Weights. 111. The weight of test specimens and of moisture samples shall be determined to an accuracy of not less than 0.2 per cent.

(*B*) *Measurements.*

Measurements. 112. Measurements of test specimens will be made to the nearest 0.01 in. except in the case of tension parallel to grain, radial shrinkage, and tangential shrinkage, when measurements will be taken to the nearest 0.001 in.

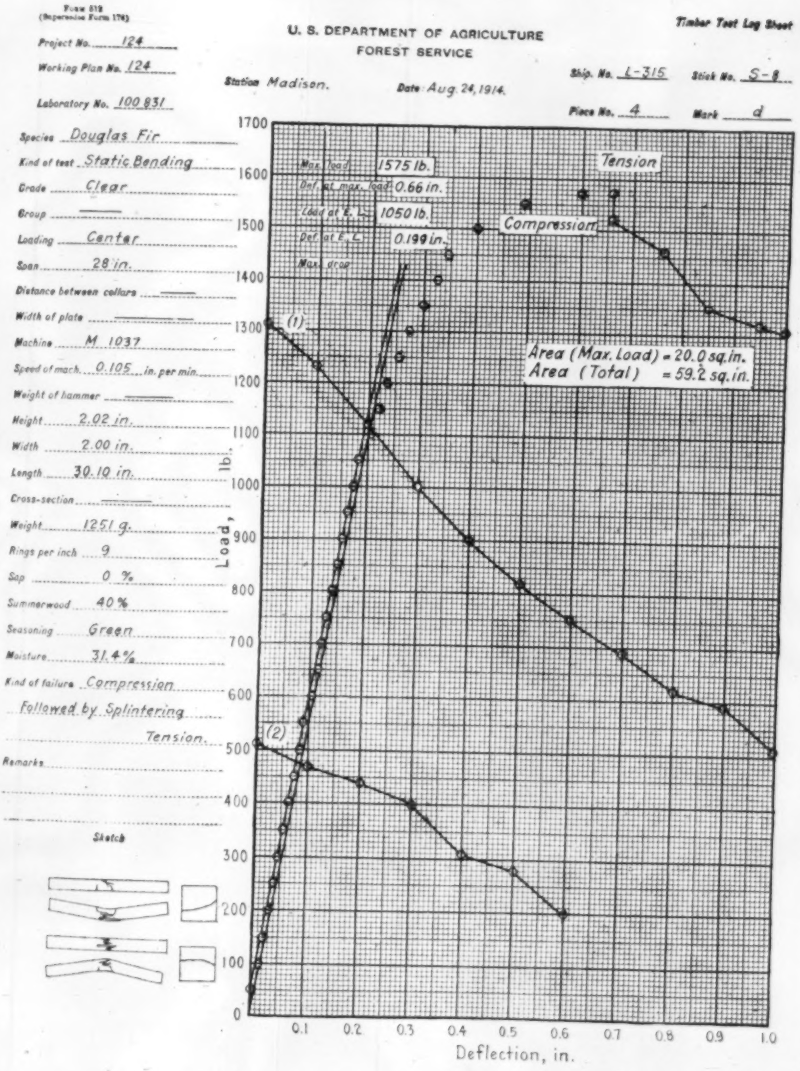
(*C*) *Testing Machine Speeds.*

Testing Machine Speeds. 113. In no case shall the testing machine speed used vary more than 25 per cent from that specified for a given test. The load shall be applied continuously, without interruption, at the required speed throughout the test.

VII. CALIBRATION.

Calibration. 114. All apparatus used in obtaining data shall be calibrated at sufficiently frequent intervals to insure accuracy.

APPENDIX.



Form 512
(Supersedes Form 176)

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Timber Test Log Sheet

Project No. 124
Working Plan No. 124
Laboratory No. 100 831
Station Madison.
Date: Aug. 24, 1914.
Ship. No. L-315
Stick No. S-8
Piece No. 4
Mark d

Species Douglas Fir
Kind of test Static Bending
Grade Clear
Group ———
Loading Center
Span 28 in.
Distance between collars ———
Width of plate ———
Machine M 1037
Speed of mach. 0.105 in. per min.
Weight of hammer ———
Height 2.02 in.
Width 2.00 in.
Length 30.10 in.
Cross-section ———
Weight 1251 g.
Rings per inch 9
Sap 0 %
Summerwood 40 %
Seasoning Green
Moisture 31.4 %
Kind of failure Compression Followed by Splintering Tension.
Remarks

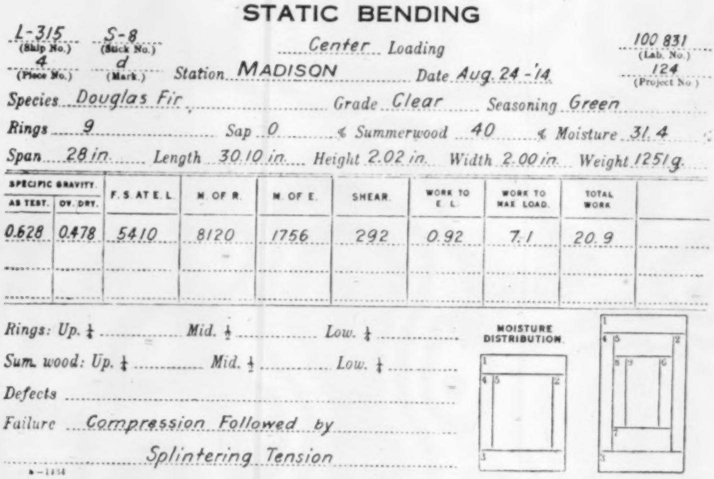
Sketch

Max. load 1575 lb.
Def. at max. load 0.66 in.
Load at E. L. 1050 lb.
Def. at E. L. 0.199 in.
Max. drop

Area (Max. Load) = 20.0 sq. in.
Area (Total) = 59.2 sq. in.

Load, lb.
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
(1)
(2)
Tension
Compression
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Deflection, in.

FIG. 1.—Sample Data Sheet for Static Bending Test.



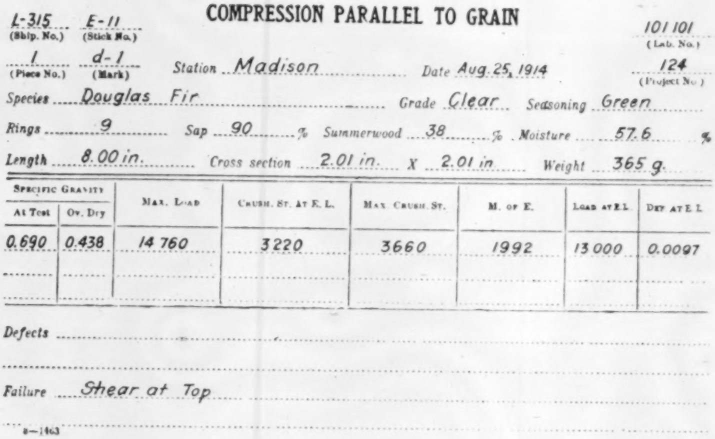
STATIC BENDING

L-315 (Ship No.) S-8 (Stick No.) Center Loading 100 831 (Lab. No.)
4 (Piece No.) d (Mark.) Station MADISON Date Aug. 24 -'14 124 (Project No.)
Species Douglas Fir Grade Clear Seasoning Green
Rings 9 Sap 0 % Summerwood 40 % Moisture 31.4 %
Span 28 in. Length 30.10 in. Height 2.02 in. Width 2.00 in. Weight 1251g.

Specific Gravity		F. S. at E. L.	M. of R.	M. of E.	Shear.	Work to E. L.	Work to Max. Load.	Total Work	
As Test.	Ov. Dry.								
0.628	0.478	5410	8120	1756	292	0.92	7.1	20.9	

Rings: Up. ¼ Mid. ½ Low. ¼
Sum. wood: Up. ¼ Mid. ½ Low. ¼
Defects
Failure Compression Followed by
Splintering Tension
a-1434

FIG. 2.—Sample Computation Data Card for Static Bending Test.



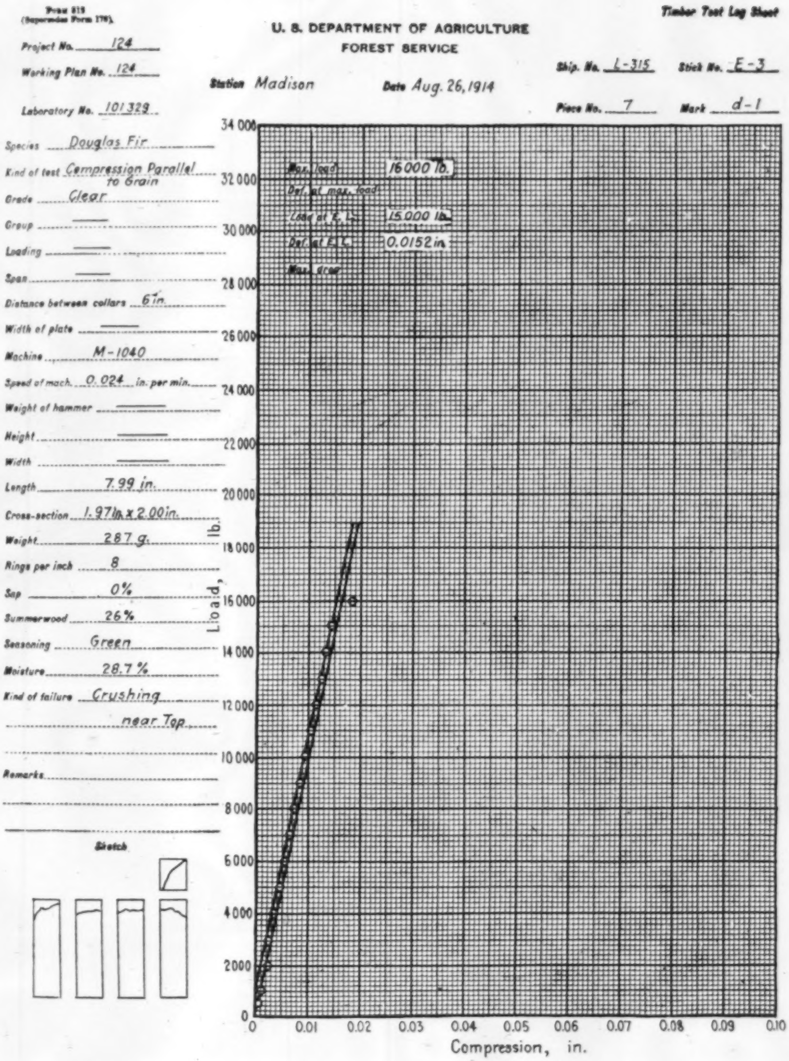
COMPRESSION PARALLEL TO GRAIN

L-315 (Ship. No.) E-11 (Stick No.) 101 101 (Lab. No.)
1 (Piece No.) d-1 (Mark) Station Madison Date Aug. 25, 1914 124 (Project No.)
Species Douglas Fir Grade Clear Seasoning Green
Rings 9 Sap 90 % Summerwood 38 % Moisture 57.6 %
Length 8.00 in. Cross section 2.01 in. X 2.01 in Weight 365 g.

Specific Gravity		Max. Load	Crush. St. at E. L.	Max. Crush. St.	M. of E.	Load at E. L.	Def. at E. L.
At Test	Ov. Dry						
0.690	0.438	14 760	3220	3660	1992	13 000	0.0097

Defects
Failure Shear at Top
a-1463

FIG. 3.—Sample Computation Data Card for Compression-Parallel-to-Grain Test.



Form 813
(Supersedes Form 178).

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Timber Test Log Sheet

Project No. 124
Working Plan No. 124
Station Madison
Date Aug. 26, 1914
Ship. No. L-315
Stick No. E-3
Laboratory No. 101329
Piece No. 7
Mark d-1

Species Douglas Fir
Kind of test Compression Parallel to Grain
Grade Clear
Group ——
Loading ——
Span ——
Distance between collars 6 in.
Width of plate ——
Machine M-1040
Speed of mach. 0.024 in. per min.
Weight of hammer ——
Height ——
Width ——
Length 7.99 in.
Cross-section 1.97 in. x 2.00 in.
Weight 287 g.
Rings per inch 8
Sap 0%
Summerwood 26%
Seasoning Green
Moisture 28.7%
Kind of failure Crushing near Top
Remarks

Sketch

Max. load 16000 lb.
Def. at max. load
Load at E. L. 15000 lb.
Def. at E. L. 0.0152 in.
Max. drop

34 000
32 000
30 000
28 000
26 000
24 000
22 000
20 000
18 000
16 000
14 000
12 000
10 000
8 000
6 000
4 000
2000
0
Load, lb.
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
Compression, in.

FIG. 4.—Sample Data Sheet for Compression-Parallel-to-Grain Test.

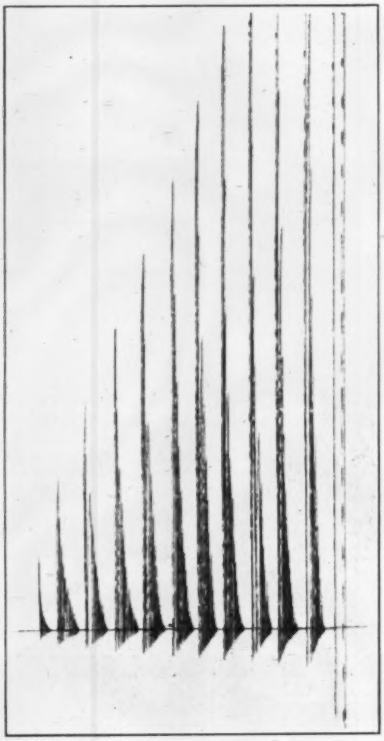
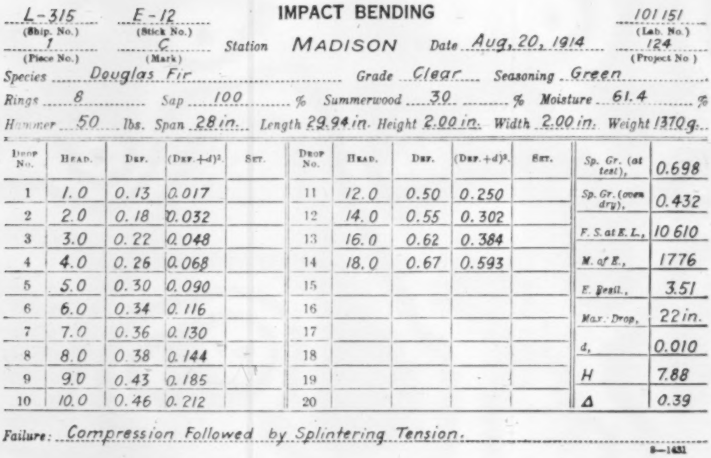


FIG. 5.—Sample Drum Record of Impact Test.



L-315 (Ship. No.)
E-12 (Stick No.)
IMPACT BENDING
101 151 (Lab. No.)

1 (Piece No.)
C (Mark)
Station MADISON
Date Aug, 20, 1914
124 (Project No.)

Species Douglas Fir
Grade Clear
Seasoning Green

Rings 8
Sap 100 %
Summerwood 30 %
Moisture 61.4 %

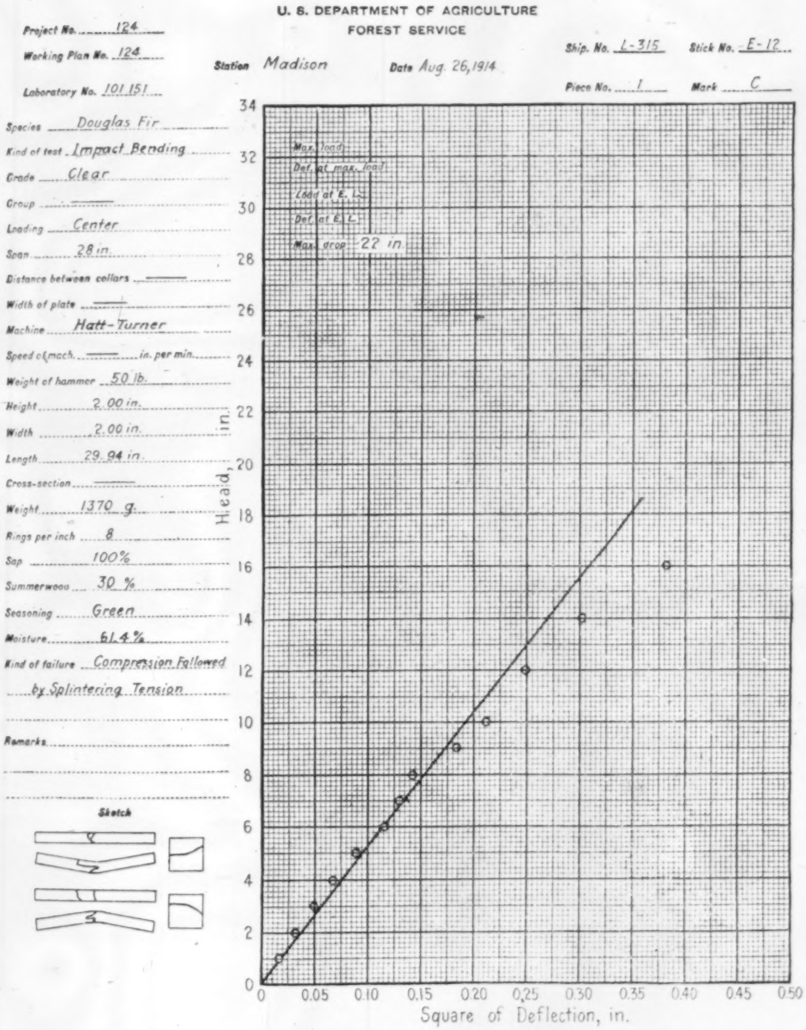
Hammer 50 lbs.
Span 28 in.
Length 29.94 in.
Height 2.00 in.
Width 2.00 in.
Weight 1370 g.

DROP No.	HEAD.	DEF.	(DEF.+d)².	SET.	DROP No.	HEAD.	DEF.	(DEF.+d)².	SET.		
										Sp. Gr. (at test),	0.698
1	1.0	0.13	0.017		11	12.0	0.50	0.250		Sp. Gr. (oven dry),	0.432
2	2.0	0.18	0.032		12	14.0	0.55	0.302			
3	3.0	0.22	0.048		13	16.0	0.62	0.384		F. S. at E. L.,	10 610
4	4.0	0.26	0.068		14	18.0	0.67	0.593		M. of E.,	1776
5	5.0	0.30	0.090		15					E. Resil.,	3.51
6	6.0	0.34	0.116		16					Max. Drop,	22 in.
7	7.0	0.36	0.130		17						
8	8.0	0.38	0.144		18					d,	0.010
9	9.0	0.43	0.185		19					H	7.88
10	10.0	0.46	0.212		20					Δ	0.39

Failure: Compression Followed by Splintering Tension.

8—1431

FIG. 6.—Sample Computation Data Card for Impact-Bending Test.



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

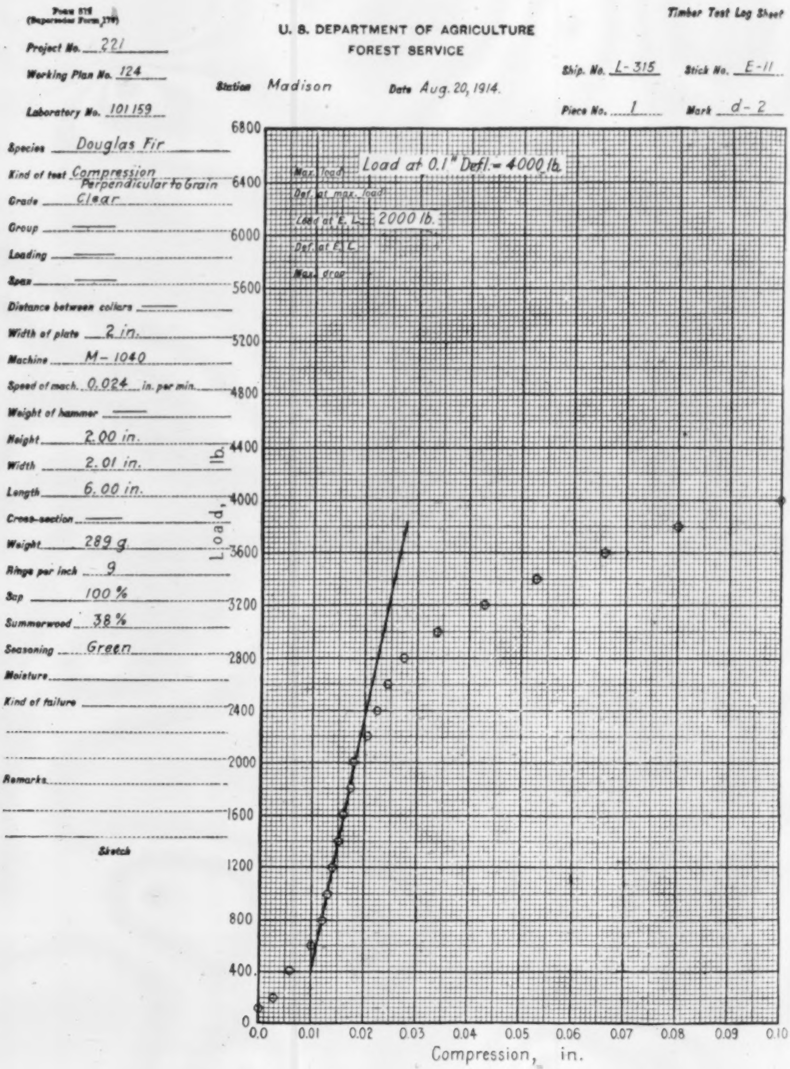
Project No. 124
Working Plan No. 124
Station Madison
Date Aug. 26, 1914
Ship. No. L-315
Stick No. E-12
Laboratory No. 101 151
Piece No. 1
Mark C

Species Douglas Fir
Kind of test Impact Bending
Grade Clear
Group ———
Loading Center
Span 28 in.
Distance between collars ———
Width of plate ———
Machine Hatt-Turner
Speed of mach. ——— in. per min.
Weight of hammer 50 lb.
Height 2.00 in.
Width 2.00 in.
Length 29.94 in.
Cross-section ———
Weight 1370 g.
Rings per inch 8
Sap 100%
Summerwood 30 %
Seasoning Green
Moisture 61.4 %
Kind of failure Compression Followed by Splintering Tension
Remarks

Max. load
Def. at max. load
Load at E. L.
Def. at E. L.
Max. drop 22 in.

Sketch
Head, in.
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Square of Deflection, in.
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50

FIG. 7.—Sample Data Sheet for Impact-Bending Test.



Form [illegible]
(Supersedes Form [illegible])

Timber Test Log Sheet

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

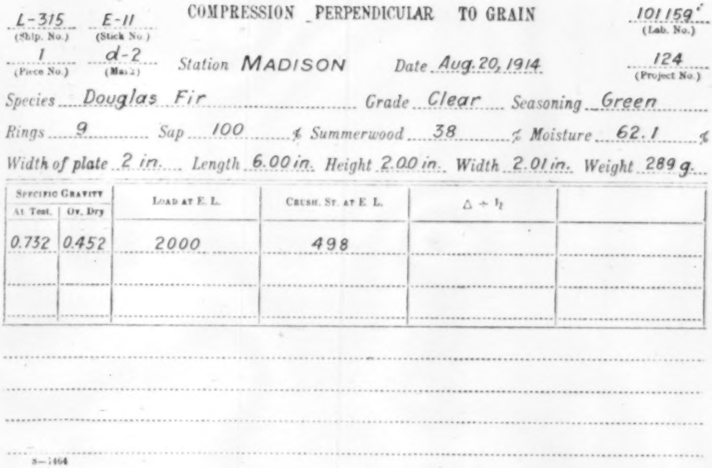
Project No. 221
Working Plan No. 124
Laboratory No. 101 159
Station Madison
Date Aug. 20, 1914.
Ship. No. L-315
Stick No. E-11
Piece No. 1
Mark d-2

Species Douglas Fir
Kind of test Compression Perpendicular to Grain
Grade Clear
Group —
Loading —
Span —
Distance between collars —
Width of plate 2 in.
Machine M-1040
Speed of mach. 0.024 in. per min.
Weight of hammer —
Height 2.00 in.
Width 2.01 in.
Length 6.00 in.
Cross-section —
Weight 289 g.
Rings per inch 9
Sap 100 %
Summerwood 38 %
Seasoning Green
Moisture
Kind of failure
Remarks
Sketch

Max. load
Def. at max. load
Load at E. L. 2000 lb.
Def. at E. L.
Max. drop
Load at 0.1" Defl. = 4000 lb.

6800
6400
6000
5600
5200
4800
4400
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
Load, lb.
0.0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
Compression, in.

FIG. 8.—Sample Data Sheet Form for Compression-Perpendicular-to-Grain Test.



COMPRESSION PERPENDICULAR TO GRAIN

L-315 (Ship. No.) E-11 (Stick No.) 101159' (Lab. No.)

1 (Piece No.) d-2 (Mark.) Station MADISON Date Aug. 20, 1914 124 (Project No.)

Species Douglas Fir Grade Clear Seasoning Green

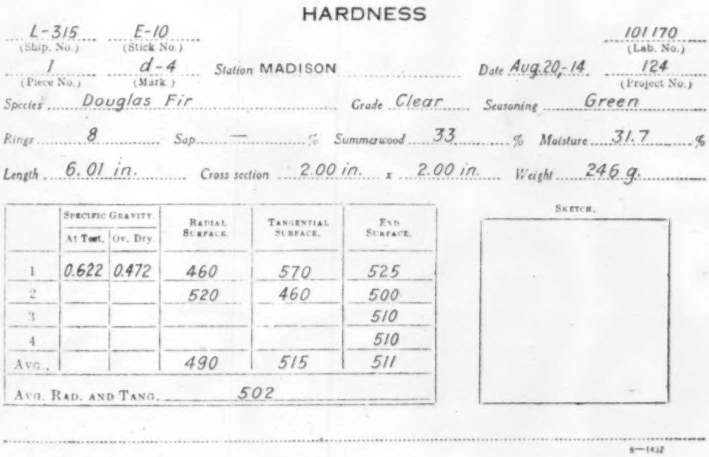
Rings 9 Sap 100 % Summerwood 38 % Moisture 62.1 %

Width of plate 2 in. Length 6.00 in. Height 2.00 in. Width 2.01 in. Weight 289 g.

Specific Gravity		Load at E. L.	Crush. St. at E. L.	Δ ÷ ½	
At Test.	Ov. Dry				
0.732	0.452	2000	498		

8—1464

FIG. 9.—Sample Computation Data Card for Compression-Perpendicular-to-Grain Test.



HARDNESS

L-315 (Ship. No.) E-10 (Stick No.) 101170 (Lab. No.)

1 (Piece No.) d-4 (Mark.) Station MADISON Date Aug. 20,-14 124 (Project No.)

Species Douglas Fir Grade Clear Seasoning Green

Rings 8 Sap — % Summerwood 33 % Moisture 31.7 %

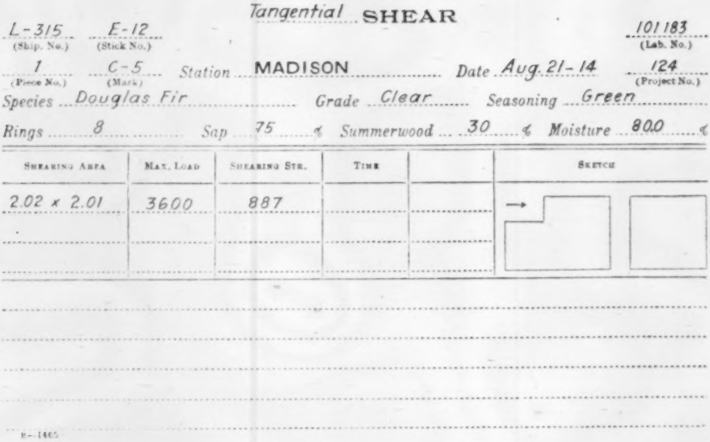
Length 6.01 in. Cross section 2.00 in. x 2.00 in. Weight 246 g.

	Specific Gravity.		Radial Surface.	Tangential Surface.	End Surface.
	At Test.	Ov. Dry			
1	0.622	0.472	460	570	525
2			520	460	500
3					510
4					510
Avg.,			490	515	511
Avg. Rad. and Tang.	502				

Sketch.

8—1432

FIG. 10.—Sample Data and Computation Card for Hardness Test.



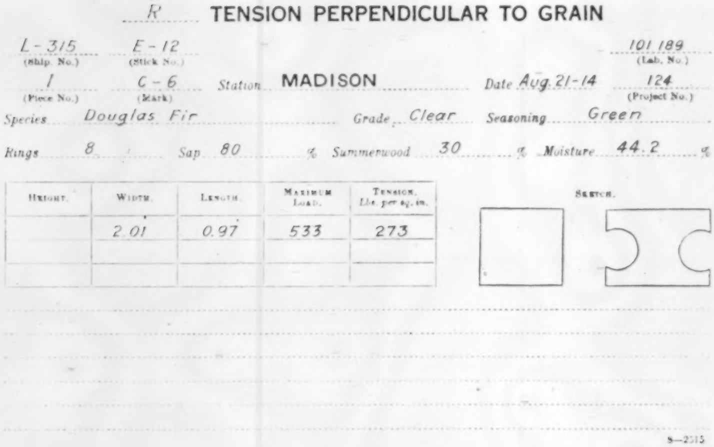
Tangential **SHEAR**

L-315 (Ship. No.) E-12 (Stick No.) 101183 (Lab. No.)
1 (Piece No.) C-5 (Mark) Station MADISON Date Aug. 21-14 124 (Project No.)
Species Douglas Fir Grade Clear Seasoning Green
Rings 8 Sap 75 % Summerwood 30 % Moisture 80.0 %

SHEARING AREA	MAX. LOAD	SHEARING STR.	TIME		SKETCH
2.02 × 2.01	3600	887			

8–1465

FIG. 11.—Sample Data and Computation Card for Tangential-Shear-Parallel-to-Grain Test. (Surface of failure tangential.)



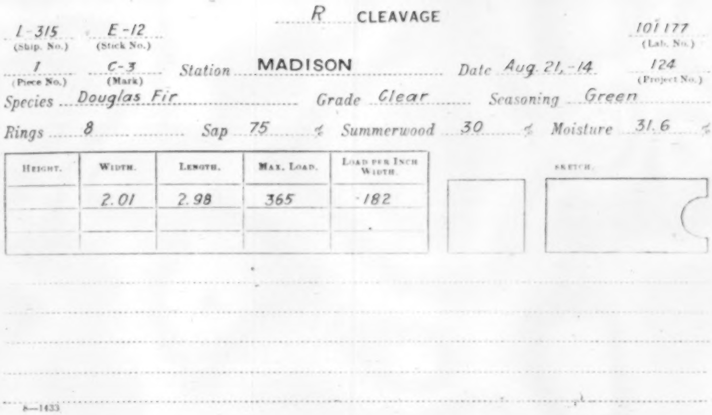
R **TENSION PERPENDICULAR TO GRAIN**

L-315 (Ship. No.) E-12 (Stick No.) 101 189 (Lab. No.)
1 (Piece No.) C-6 (Mark) Station MADISON Date Aug. 21-14 124 (Project No.)
Species Douglas Fir Grade Clear Seasoning Green
Rings 8 Sap 80 % Summerwood 30 % Moisture 44.2 %

HEIGHT.	WIDTH.	LENGTH.	MAXIMUM LOAD.	TENSION. Lbs. per sq. in.
	2.01	0.97	533	273

8—2515

FIG. 12.—Sample Data and Computation Card for Radial-Tension-Perpendicular-to-Grain Test. (Surface of failure radial.)



R CLEAVAGE

I-315 (Ship. No.) E-12 (Stick No.) 101 177 (Lab. No.)

1 (Piece No.) C-3 (Mark) Station MADISON Date Aug. 21, -14 124 (Project No.)

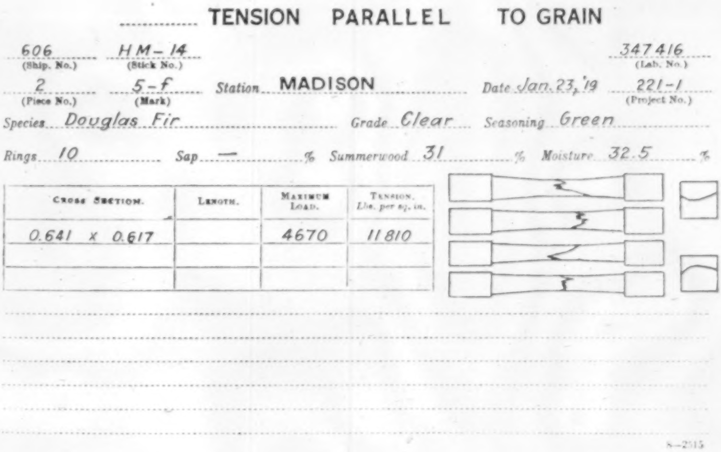
Species Douglas Fir Grade Clear Seasoning Green

Rings 8 Sap 75 % Summerwood 30 % Moisture 31.6 %

Height.	Width.	Length.	Max. Load.	Load per Inch Width.
	2.01	2.98	365	182

8—1433

FIG. 13.—Sample Data and Computation Card for Radial-Cleavage Test. (Surface of failure radial.)



TENSION PARALLEL TO GRAIN

606 (Ship. No.) HM-14 (Stick No.) 347416 (Lab. No.)

2 (Piece No.) 5-f (Mark) Station MADISON Date Jan. 23, '19 221-1 (Project No.)

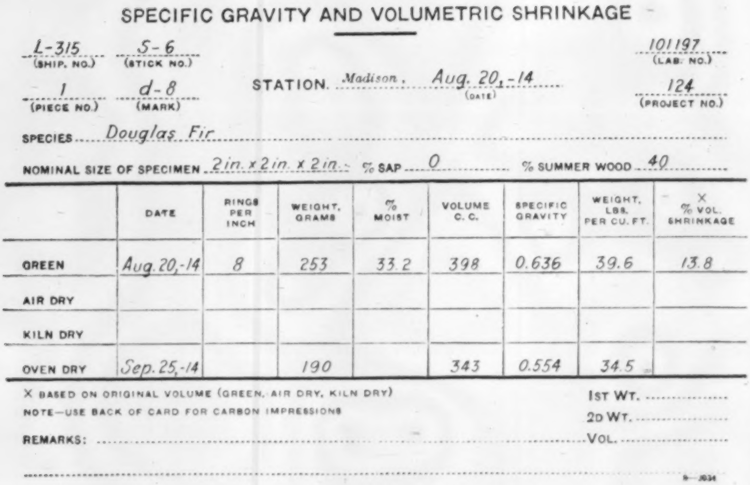
Species Douglas Fir Grade Clear Seasoning Green

Rings 10 Sap — % Summerwood 31 % Moisture 32.5 %

Cross Section.	Length.	Maximum Load.	Tension. Lbs. per sq. in.
0.641 x 0.617		4670	11810

8—2315

FIG. 14.—Sample Data and Computation Card for Tension-Parallel-to-Grain Test.



SPECIFIC GRAVITY AND VOLUMETRIC SHRINKAGE

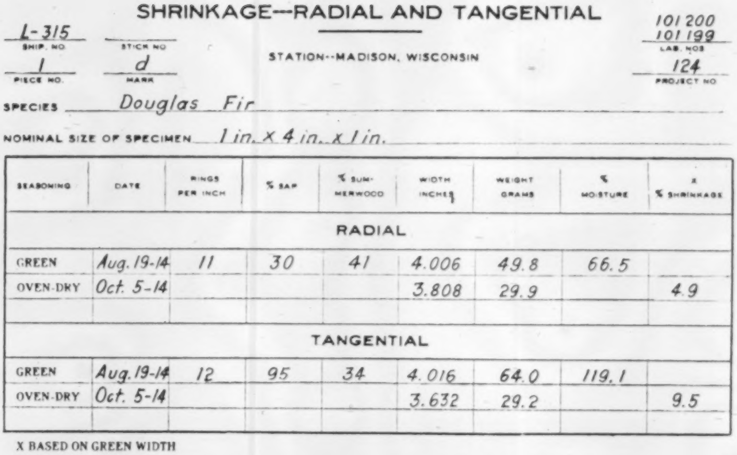
L-315 (SHIP. NO.) 5-6 (STICK NO.) 101197 (LAB. NO.)
1 (PIECE NO.) d-8 (MARK) STATION. Madison. Aug. 20,-14 (DATE) 124 (PROJECT NO.)
SPECIES Douglas Fir
NOMINAL SIZE OF SPECIMEN 2 in. x 2 in. x 2 in. % SAP 0 % SUMMER WOOD 40

	DATE	RINGS PER INCH	WEIGHT, GRAMS	% MOIST	VOLUME C. C.	SPECIFIC GRAVITY	WEIGHT, LBS. PER CU. FT.	X % VOL. SHRINKAGE
GREEN	Aug. 20,-14	8	253	33.2	398	0.636	39.6	13.8
AIR DRY								
KILN DRY								
OVEN DRY	Sep. 25,-14		190		343	0.554	34.5	

X BASED ON ORIGINAL VOLUME (GREEN, AIR DRY, KILN DRY)
NOTE—USE BACK OF CARD FOR CARBON IMPRESSIONS
REMARKS:
1ST WT.
2D WT.
VOL.

9—2034

FIG. 15.—Sample Data and Computation Card for Specific Gravity and Shrinkage-in-Volume Test.



SHRINKAGE—RADIAL AND TANGENTIAL

L-315 SHIP. NO. STICK NO 101200 101199 LAB. NOS
1 PIECE NO. d MARK STATION—MADISON, WISCONSIN 124 PROJECT NO
SPECIES Douglas Fir
NOMINAL SIZE OF SPECIMEN 1 in. x 4 in. x 1 in.

SEASONING	DATE	RINGS PER INCH	% SAP	% SUMMERWOOD	WIDTH INCHES	WEIGHT GRAMS	% MOISTURE	X % SHRINKAGE
RADIAL								
GREEN	Aug. 19-14	11	30	41	4.006	49.8	66.5	
OVEN-DRY	Oct. 5-14				3.808	29.9		4.9
TANGENTIAL								
GREEN	Aug. 19-14	12	95	34	4.016	64.0	119.1	
OVEN-DRY	Oct. 5-14				3.632	29.2		9.5

X BASED ON GREEN WIDTH

FIG. 16.—Sample Data and Computation Card for Radial and Tangential-Shrinkage Tests.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING BELOW GROUND LEVEL.[1]

Serial Designation: D 40 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1917; REVISED, 1922.

Scope. 1. These specifications cover asphalt suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing below ground level, under uniformly moderate temperature conditions.[2]

2. The grade of asphalt covered in these specifications is suitable for damp-proofing and waterproofing foundations, tunnels, subways, etc.

I. SAMPLING.

Sampling. 3. The sampling shall be performed in accordance with the Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums (Serial Designation: D 148 - 22 T) of the American Society for Testing Materials.[3]

II. PROPERTIES.

Properties. 4. The asphalt shall be homogeneous and free from water. It shall meet the following requirements:

(*a*) Softening point by the Ring-and-Ball method..................115 to 145° F. (46.1 to 62.7° C.)

(*b*) Penetration at 25° C. (77° F.), 100 g., 5 sec...................................50 to 100

(*c*) Flash point (open cup).......not less than 347° F. (175° C.)

(*d*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.....................not more than 2 per cent

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Such asphalt is not intended to be heated above 400° F. (204.4° C.) during its application.

[3] See p. 890.

(*e*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt before heating........................not less than 60 per cent

(*f*) Ductility at 25° C. (77° F.)..............not less than 30 cm.

(*g*) Insoluble in carbon disulfide........not more than 5 per cent

III. METHODS OF TESTING.

Methods of Testing. 5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*f*):

(*a*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials other than Tar Products (Ring-and-Ball Method) (Serial Designation: D 36).[1]

(*b*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[1]

(*c*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 21 T).[2]

(*d*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[1]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T).[3]

(*f*) *Insoluble in Carbon Disulfide:* Method contained in *Bulletin 949*, U. S. Department of Agriculture, p. 38.

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[3] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATER-PROOFING ABOVE GROUND LEVEL.[1]

Serial Designation: D 144 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope.

1. These specifications cover asphalt suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing above ground level, where not exposed to a temperature exceeding 100° F. (37.7° C.).[2]

2. The grade of asphalt covered in these specifications is suitable for damp-proofing and waterproofing railroad bridges, tanks, retaining walls, embankments, culverts, dams, conduits, etc.

I. SAMPLING.

Sampling.

3. The sampling shall be performed in accordance with the Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums (Serial Designation: D 148 – 22 T) of the American Society for Testing Materials.[3]

II. PROPERTIES.

Properties.

4. The asphalt shall be homogeneous and free from water. It shall meet the following requirements:

(*a*) Softening point by the Ring-and-Ball method	150 to 190° F. (65.5 to 87.7° C.)
(*b*) Penetration at 25° C. (77° F.), 100 g., 5 sec.	30 to 50
Penetration at 0° C. (32° F.), 200 g., 60 sec.	not less than 10

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Such asphalt is not intended to be heated above 450° F. (232.2° C.) during its application.

[3] See p. 890.

(*c*) Flash point (open cup) .... not less than 400° F. (204.4° C.)

(*d*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr. .... not more than 1 per cent

(*e*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt before heating .... not less than 60 per cent

(*f*) Ductility at 25° C. (77° F.) .... not less than 3 cm.

(*g*) Insoluble in carbon disulfide .... not more than 5 per cent.

III. METHODS OF TESTING.

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*f*):

(*a*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials other than Tar Products (Ring-and-Ball Method) (Serial Designation: D 36).[1]

(*b*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[1]

(*c*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 21 T).[2]

(*d*) *Loss on Heating:* Standard Method of Test for loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[1]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T).[3]

(*f*) *Insoluble in Carbon Disulfide:* Method described in *Bulletin 949*, U. S. Department of Agriculture, p. 38.

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 651 (1921).

[3] See p. 807.

TENTATIVE SPECIFICATIONS

FOR

PRIMER FOR USE WITH ASPHALT IN DAMP-PROOFING AND WATERPROOFING BELOW AND ABOVE GROUND LEVEL.[1]

Serial Designation: D 41 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1917; REVISED, 1922.

Scope. 1. These specifications cover asphaltic primer for use, when specified, with asphalt in damp-proofing and waterproofing below or above ground level, for application to concrete and masonry surfaces.

I. SAMPLING.

Sampling. 2. From each shipment or portion thereof representing primer of the same kind, a number of packages shall be selected at random equivalent to the cube root of the total number of packages in the lot. If the cube root as calculated proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

PACKAGES IN SHIPMENT.	PACKAGES SELECTED.	PACKAGES IN SHIPMENT.	PACKAGES SELECTED.
2 to 8	2	217 to 343	7
9 to 27	3	344 to 512	8
28 to 64	4	513 to 729	9
65 to 125	5	730 to 1000	10
126 to 16	6	1001 to 1331	11

3. By means of a paddle, the contents of each package selected shall be thoroughly stirred so as to bring all portions thereof into uniform distribution. With an appropriate sampler, not less than 1 pt. of the primer shall be immediately drawn from the center of each package, and transferred to a clean receptacle of suitable size, which in turn shall be kept tightly covered, prior and immediately after said

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

samples are being introduced. After all the pint samples have been added, the contents of the container shall be thoroughly agitated, whereupon 1 qt. of the mixture shall immediately be transferred to a clean quart can provided with a tightly fitting screw cap, which shall be immediately fastened in place. This sample shall be considered as representative of the shipment and shall be transmitted to the laboratory for examination, bearing a suitable tag or other means of identification.

II. PROPERTIES.

Asphaltic Base.

4. The asphaltic base used in preparing the primer shall meet the requirements specified in the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (Serial Designation: D 40 – 22 T).[1]

Solvent.

5. The solvent used in preparing the primer shall be a hydrocarbon distillate having an end point on distillation of not above 250° C. (500° F.), of which not more than 20 per cent shall distill under 120° C. (248° F.).

6. The primer shall be free from water and shall conform to the following requirements:

(*a*) Sediment	not more than 1 per cent
(*b*) Asphaltic base by weight	25 to 35 "

III. METHODS OF TESTING.

Methods of Testing.

7. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials except as specified in Paragraph (*c*):

(*a*) *Distillation:* Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 – 21 T).[2]

(*b*) *Sediment:* Tentative Method of Test for Water and Sediment in Petroleum Products, by Means of Centrifuge (Serial Designation: D 96 – 21 T.)[3]

(*c*) *Weight of Asphaltic Base Present:* The distillation method contained in *Technologic Paper No. 76*, Bureau of Standards, June 21, 1916.

("Determination of Volatile Thinner in Oil Varnish," by E. W. Boughton.)

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[1] See p. 863.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 631 (1921).

[3] *Ibid.*, p. 670.

TENTATIVE SPECIFICATIONS

FOR

COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING BELOW GROUND LEVEL.[1]

Serial Designation: D 42 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1917; REVISED, 1922.

1. These specifications cover coal-tar pitch suitable for use as a mopping-coat in damp-proofing or as a plying-cement in the construction of a membrane system of waterproofing below ground level, under uniformly moderate temperature conditions.[2] **Scope.**

2. The grade of coal-tar pitch covered by these specifications is suitable for damp-proofing and waterproofing foundations, tunnels, subways, etc.

I. SAMPLING.

3. The sampling shall be performed in accordance with the Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums (Serial Designation: D 148 – 22 T) of the American Society for Testing Materials.[3] **Sampling.**

II. PROPERTIES.

4. The coal-tar pitch shall be homogeneous and shall meet the following requirements: **Properties.**

(*a*) Water....................................0.0 per cent
(*b*) Specific gravity at 25°/25° C. (77°/77° F.)....1.24 to 1.34
(*c*) Softening Point[4] (Cube-in-Water Method)................110 to 140°F. (43.3 to 60.0° C.)
(*d*) Distillation Test:

Total distillate, by weight, 0.0 to 300° C. (32 to 572° F.)......................not more than 12.0 per cent
Residue, by weight......................not less than 88.0 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Such coal-tar pitch is not intended to be heated above 300° F. (148.8° C.) during its application.

[3] See p. **890**.

[4] The softening point (Cube-in-Water Method) specified should have a range of not over 10° F. within the limits given in Section 4 (*c*).

(*e*) Specific gravity at 25°/25° C. (77°/77° F.) of total distillate to 300° C. (572° F.) ....not less than 1.03
(*f*) Ductility at 25° C. (77° F.)........... not less than 50 cm.
(*g*) Insoluble in carbon disulfide...............20 to 35 per cent

III. METHODS OF TESTING.

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*f*):

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Bituminous Materials (Serial Designation: D 114 – 21 T).[1]

(*b*) *Specific Gravity:* Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (Serial Designation: D 70 – 20 T).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[3]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20).[3]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T).[4]

(*f*) *Insoluble in Carbon Disulfide:* Method described in *Bulletin 949*, U. S. Department of Agriculture, p. 38.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 706 (1921).
[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 764 (1920).
[3] 1921 Book of A.S.T.M. Standards.
[4] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING ABOVE GROUND LEVEL.[1]

Serial Designation: D 145 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope. 1. These specifications cover coal-tar pitch suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing above ground level, when not exposed to a temperature exceeding 100° F. (37.7° C.).[2]

2. The grade of coal-tar pitch covered in these specifications is suitable for damp-proofing and waterproofing railroad bridges, tanks, retaining walls, embankments, culverts, dams, conduits, etc.

I. SAMPLING.

Sampling. 3. The sampling shall be performed in accordance with the Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums (Serial Designation: D 148 – 22 T) of the American Society for Testing Materials.[3]

II. PROPERTIES.

Properties. 4. The coal-tar pitch shall be homogeneous and shall meet the following requirements:

(*a*) Water..0.0 per cent

(*b*) Specific gravity at 25°/25° C. (77° /77° F.).....1.25 to 1.35

(*c*) Softening Point (Cube-in-Water Method)...............130 to 155° F. (54.4 to 68.3° C.)

(*d*) Distillation Test:

Total distillate, by weight, 0 to 300° C. (32 to 572° F.)........................not more than 10.0 per cent

Residue, by weight.....................not less than 90.0 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Such coal-tar pitch is not intended to be heated above 350° F. (176.6° C.) during its application.

[3] See p. 890.

[4] The softening point (Cube-in-Water Method) should have a range of not over 10° F. within the limits given in Section 4 (*c*).

(*e*) Specific gravity at 25°/25° C. (77°/77° F.)
of total distillate to 300° C. (572° F.)..not less than 1.03
(*f*) Ductility at 25° C. (77° F.)............not less than 15 cm.
(*g*) Insoluble in carbon disulfide..............22 to 37 per cent

III. METHODS OF TESTING.

Methods of Testing. 5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*f*):

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Bituminous Materials (Serial Designation: D 114 - 21 T).[1]

(*b*) *Specific Gravity:* Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (Serial Designation: D 70 - 20 T).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[3]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20).[3]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T).[4]

(*f*) *Insoluble in Carbon Disulfide:* Method described in *Bulletin 649*, U. S. Department of Agriculture, p. 38.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 706 (1921).

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 764 (1920).

[3] 1921 Book of A.S.T.M. Standards.

[4] See p. 807.

TENTATIVE SPECIFICATIONS
FOR
CREOSOTE OIL FOR PRIMING COAT WITH COAL-TAR PITCH IN DAMP-PROOFING AND WATERPROOFING BELOW AND ABOVE GROUND LEVEL.[1]

Serial Designation: D 43 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1917; REVISED, 1922.

Scope. 1. These specifications cover creosote oil primer for use, when specified, with coal-tar pitch in damp-proofing and waterproofing below or above ground level, for application to concrete and masonry surfaces.

I. SAMPLING.

Sampling. 2. From each shipment or portion thereof representing creosote oil of the same kind, a number of packages shall be selected at random equivalent to the cube root of the total number of packages in the lot. If the cube root as calculated proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

PACKAGES IN SHIPMENT.	PACKAGES SELECTED.	PACKAGES IN SHIPMENT.	PACKAGES SELECTED.
2 to 8	2	217 to 343	7
9 to 27	3	344 to 512	8
28 to 64	4	513 to 729	9
65 to 125	5	730 to 1000	10
126 to 216	6	1001 to 1331	11

3. By means of a paddle, the contents of each package selected shall be thoroughly stirred so as to bring all portions thereof into uniform distribution. With an appropriate sampler, not less than 1 pt. of the creosote oil shall be immediately drawn out from the center of each package and transferred to a clean receptacle of suit-

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

able size, which in turn shall be kept tightly covered, prior and immediately after said samples are being introduced. After all the pint samples have been added, the contents of the container shall be thoroughly agitated, whereupon 1 qt. of the mixture shall immediately be transferred to a clean quart can provided with a tightly fitting screw cap, which shall be immediately fastened in place. This sample shall be considered as representative of the shipment and shall be transmitted to the laboratory for examination, bearing a suitable tag or other means of identification.

II. PROPERTIES.

Properties.

4. The creosote oil primer shall meet the following requirements:

(*a*) Water.........................not more than 2 per cent
(*b*) Consistency at 38° C. (100° F.)..............entirely fluid
(*c*) Specific gravity at 38°/25° C. (100°/77° F.)......1.00 to 1.06
(*d*) Insoluble in benzol.............not more than 1 per cent
(*e*) Distillation Test:

Total distillate, by weight, under 200° C. (392° F.)............................not more than 5 per cent
Total distillate, by weight, under 235° C. (455° F.).............not more than 50 nor less than 30 "
Residue, by weight, above 355° C. (671° F.).. not more than 15 "

(*f*) Specific gravity at 38°/25° C. (100°/77° F.) of the fraction distilling between 235 and 315° C. (455 and 599° F.)............not less than 1.00
(*g*) Consistency at 25° C. (77° F.) of the residue........ soft

III. METHODS OF TESTING.

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials.[1]

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[1] 1921 Book of A.S.T.M. Standards.

TENTATIVE METHODS OF TESTING FELTED AND WOVEN FABRICS SATURATED WITH BITUMINOUS SUBSTANCES FOR USE IN WATERPROOFING.[1]

Serial Designation: D 146 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Scope. 1. These methods cover the examination of felted or woven fabrics saturated (but not coated) with asphalt or coal-tar products, for use in the "membrane" system of waterproofing.

I. SAMPLING.

Sampling. 2. From each shipment or portion thereof representing a product of the same kind, class and weight, a number of rolls shall be selected at random, equivalent to the cube root of the total number of rolls in the lot. If the cube root, as calculated, proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

Packages in Shipment.	Number of Packages Selected.	Packages in Shipment.	Number of Packages Selected.
2 to 8	2	1332 to 1728	12
9 to 27	3	1729 to 2197	13
28 to 64	4	2198 to 2744	14
65 to 125	5	2745 to 3375	15
126 to 216	6	3376 to 4096	16
217 to 343	7	4097 to 4913	17
344 to 512	8	4914 to 5832	18
513 to 729	9	5833 to 6859	19
730 to 1000	10	6860 to 8000	20
1001 to 1331	11	8001 to 9261	21

II. EXAMINATION OF FINISHED FABRIC.

Width. 3. The width of each roll taken shall be measured to the nearest $\frac{1}{32}$ in. The minimum, maximum and average width so obtained shall be reported.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

Gross Weight per Roll.

4. Each roll taken shall be weighed intact to the nearest $\frac{1}{4}$ lb. and the minimum, maximum and average gross weight shall be reported.

Wrapping and Packing Materials.

5. Each roll sampled shall be stripped. All the wrappers and packing material shall be weighed together to the nearest $\frac{1}{4}$ lb. and the average weight shall be reported. Each roll should be temporarily fastened with a piece of light string and handled carefully, so as not to disturb any detached surfacing material.

Net Weight per Roll.

6. The minimum, maximum and average net weight per roll shall be calculated by subtracting the average weight of the wrapping and packing material as determined in Section 5 from the average gross weight as determined in Section 4.

Weight per Unit Area.

7. Each roll sampled shall be laid flat, the first convolution or two carefully unwound, and with a knife and straight edge the sheet shall be cleanly cut across at right angles to the edges. A section measuring 30 in. in the direction of the roll's length shall be removed. If the material is surfaced with sand or other fine material any detached particles belonging to each 30-in. section should be retained. The width of each section shall be measured to the nearest $\frac{1}{32}$ in. Each section, together with any detached surfacing, shall be weighed to the nearest gram. The weight in pounds per 100 sq. ft. shall be calculated from the formula:

$$\text{Weight per 100 sq. ft.} = 1.0582 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

From the results obtained for each roll sampled, the minimum, maximum, and average weight in pounds per 100 sq. ft. shall be calculated.

NOTE.—As a referee method or in case any dispute arises regarding the weight "per unit area," the method described in Section 8 shall be followed. From the net weight of each roll determined as in Section 6, the weight per unit area may be calculated as a check.

Area per Roll.

8. The average area per roll in square feet shall be calculated by dividing the average net weight per roll, as determined in Section 6, by the average weight in pounds per 100 sq. ft. as determined in Section 7, and multiplying by 100.

NOTE.—As a referee method or in case any dispute arises regarding the "area per roll" as calculated, each roll sampled shall be unwound and the total length measured within $\frac{1}{4}$ in. with a steel tape. From the width of each roll, as determined in Section 3, the "area per roll" may be accurately calculated as a check and the minimum, maximum and average for the shipment calculated.

Detached Comminuted Surfacing.

9. If the material is surfaced with sand or other finely comminuted material, the surfacing shall be swept with a moderately stiff brush from all the 30-in. sections taken. All the material thus removed shall

be caught and weighed to the nearest ounce. From the aggregate areas of all the sections taken, the average weight of detached comminuted surfacing shall be calculated in pounds per 100 sq. ft.

Thickness. 10. The thickness of each specimen shall be measured at 10 equally spaced points, 1 in. from a cut edge, with a micrometer gage having flat bearing surfaces at both contact points of not less than ½ in. in diameter and preferably of the spring-and-dial type. The readings for each rolled sample shall be averaged and the minimum, maximum and average thickness calculated to the nearest 0.001 in.

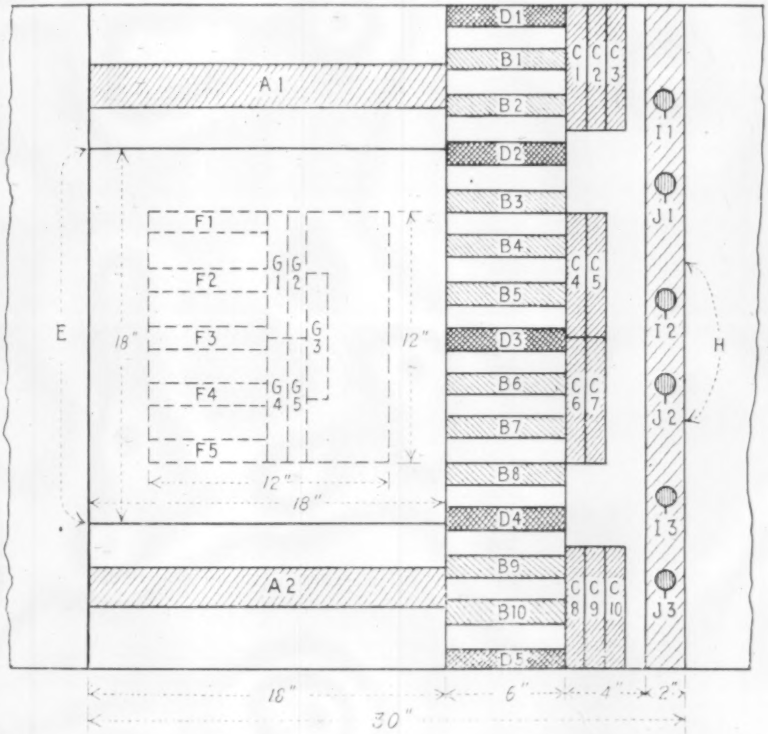
D1
B1
C 1
C 2
C 3
A 1
B2
I 1
D2
J 1
B3
F1
G 1
G 2
F2
B4
C 4
C 5
B5
I 2
E
18"
F3
G 3
12"
D3
H
B6
C 6
C 7
F4
G 4
G 5
J 2
B7
F5
12"
B8
18"
D4
I 3
A 2
B9
C 8
C 9
C 10
J 3
B10
D5
18"
6"
4"
2"
30"

FIG. 1

Moisture. 11. From each specimen, 2-in. strips shall be cut as shown at *A-1* and *A-2* in Fig. 1. The 2-in. strips shall be cut into 1-in. squares. About 50 g., selected at random, shall be accurately weighed and distilled with 100 cc. of water-saturated solvent naphtha (crude xylol) in an apparatus of the form and under the conditions prescribed in the Tentative Method of Test for Water in Petroleum Products (Serial

Designation: D 95 - 21 T) of the American Society for Testing Materials.[1] The flask containing the xylol and sample shall be heated in a paraffin bath at a temperature of 302 to 338° F. (150 to 170° C.) until no further distillate passes over. The distillate shall be allowed to stand in the graduated receiver or centrifuged until the water separates, whereupon the volume of water shall be measured and its weight calculated. From this, the average percentage of moisture in the fabric, as received, shall be calculated.

Strength. 12. (*a*) *Felted Fabrics.*—With a photographic trimmer having a stop attached exactly 1 in. behind the blade, ten strips shall be cut with the fiber grain, as shown at *B-1* to *B-10* (Fig. 1) and ten strips across the fiber grain as shown at *C-1* to *C-10*. Each strip should measure 6 in. and have parallel sides 1 in. apart (within $\frac{1}{32}$ in.) with the edges cut straight and clean. Both sets of strips shall be tested at 77° F. (25° C.), using a tension testing machine such as the Scott Strength Tester (Type F, 100 lb. capacity), the Perkins Strip Tester, or equal, in which the clamps are attached to swivels free to move in any direction. The test strips shall be gripped $1\frac{1}{2}$ in. on each end, leaving approximately 3 in. between the clamps. The tension shall be increased at a uniform speed of 3 lb. per second, using a metronome. If any strip breaks nearer than $\frac{1}{2}$ in. to either clamp, the reading shall be disregarded, and an additional strip shall be tested in its place. The ten readings, with and across the grain, respectively, shall be averaged for each roll sampled. From these results the minimum, maximum and average strength with and across the fiber grain, respectively, of the fabric as supplied, shall be calculated.

(*b*) *Woven Fabrics.*—Woven fabrics shall be tested at 77° F. (25° C.) in accordance with the "grab test" as described in Section 12 (*b*) of the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[2] (Note.—The percentage elongation before rupture may also be recorded.)

Pliability. 13. With the trimmer described in Section 12 (*a*), five 6-in. strips shall be cut with the fiber grain, as shown at *D-1* to *D-5* (Fig. 1) and immersed in water at 77° F. (25° C.) for 15 minutes. These strips shall be bent through 180 deg. at a uniform speed, in exactly 2 seconds, around a pin, the diameter of which shall be as follows: The first, around a pin 25 mm. in diameter; the second, around a pin 20 mm. in diameter; the third, around a pin 15 mm. in diameter; the fourth, around a pin 10 mm. in diameter, and the fifth, around a pin 5 mm.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 666 (1921).

[2] 1921 Book of A.S.T.M. Standards.

in diameter. The pliability shall be expressed numerically from 1 to 10 as follows:

(1) Cracks entirely through the sheet on the 25-mm. pin.
(2) Cracks part way through the sheet on the 25-mm. pin.
(3) Cracks on the 25-mm. pin.
(4) Cracks on the 20-mm. pin.
(5) Cracks on the 15-mm. pin.
(6) Cracks on the 10-mm. pin.
(7) Cracks on the 5-mm. pin.
(8) Cracks when bent through 180 deg. flat on itself.
(9) May be bent through 180 deg. flat on itself in one direction without cracking, but will crack when bent through 360 deg. in the opposite direction.
(10) May be bent through 180 deg. flat on itself in one direction and then through 360 deg. flat on itself in the opposite direction without cracking.

The readings for each roll shall be averaged separately, and from these results the minimum, maximum and average pliability of the felt shall be calculated.

Water Absorbed.

14. (*a*) A section 18 in. square (as shown at *E*, Fig. 1) shall be cut from each specimen, weighed, and completely immersed in distilled water at 77° F. (25° C.) for 24 hours. The specimen shall then be removed and dried superficially by pressing lightly between two towels. As the moisture enters through the edges of the sheet more rapidly than through the surfaces, each specimen shall be trimmed to exactly 12 in. square, representing four-ninths of the original area, and reweighed rapidly. The increase in weight shall be calculated on the basis of the original test specimen by multiplying by $2\frac{1}{4}$. The percentage increase in weight represents the water absorption. The minimum, maximum and average for the shipment shall be calculated.

(*b*) Five strips shall be cut with the fiber grain as shown at *F 1* to *F 5* (Fig. 1); five other strips shall be cut across the fiber grain as shown at *G 1* to *G 5* (Fig. 1) and the strength shall be redetermined as in Section 12. The decrease in strength in percentage shall be calculated after the specimen has been subjected to water.

III. DESATURATING THE FABRIC.

15. From each roll sampled, a 2-in. strip (within $\frac{1}{32}$ in.) shall be cut across the specimen as shown at *H* (Fig. 1). Each strip shall be extracted with c. p. benzol in an extractor described in Section 4 of the Tentative Methods of Testing Bituminous Mastics, Grouts and

Like Mixtures (Serial Designation: D 147 - 22 T) of the American Society for Testing Materials,[1] the extraction being continued for several hours after the drippings have become colorless. The desaturated fabric shall be removed and heated in a ventilated oven at 225° F. (107.1° C.), cooled in a desiccator, any adhering comminuted surfacing being brushed off and retained, and weighed as rapidly as possible. The heating shall be repeated until the weight of the fabric remains constant as determined by two consecutive weighings taken not less than ten minutes apart which shall show a further loss of not more than 0.1 per cent. This will give the weight of the fabric in the moisture-free state.

NOTE.—The following colorimetric method for determining foreign matter adhering to the surface of the desaturated felt, such as carbonaceous matter derived from a coal-tar pitch saturant, is published by the committee, without as yet having been conclusively tried out, that the committee might receive comments or criticisms from those interested.

16. (*a*) About 15 g. of an unsaturated fabric of the same general character as the one under examination, shall be macerated by boiling in water, disintegrating with a rotary egg-beater and picking the fibers apart with needles. The fibers shall be filtered through fine cloth and dried at a temperature of 225° F. (107.1° C.) to constant weight. One gram of the fibers shall be accurately weighed into a flask and diluted to exactly 100 cc. with distilled water at room temperature. About 50 g. of glass beads shall be added and the contents of the flask shaken vigorously until the fibers are reduced to a homogeneous pulp in uniform suspension.

(*b*) A distilled coal-tar, having approximately 10 to 25 per cent of insoluble carbonaceous matter, shall be procured and the carbonaceous matter extracted with benzol until it is free from soluble matter; then dried at a temperature of 225° F. (107.1° C.) to constant weight. One gram of the purified carbonaceous matter shall be accurately weighed and diluted to exactly 100 cc. at room temperature with a starch solution of a consistency sufficient to carry the carbonaceous matter into temporary suspension. (A 12.5-per-cent solution is recommended.)

(*c*) The liquid carrying the fibers, obtained as described in Paragraph (*a*), shall be titrated with the suspension of carbonaceous matter, obtained as described in Paragraph (*b*), and from time to time a field prepared from a drop of the well agitated mixture shall be examined under a microscope at 100 diameters magnification until the color exactly matches a field prepared from the desaturated fabric under examination (obtained as described in Section 15), when both are viewed side by side under parallel conditions. The end-point is fairly sharply defined. The burette reading gives directly the percentage of carbonaceous matter adhering to the moisture-free fabric under examination.

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[1] See p. 884.

17. The weight of bituminous matter in the original fabric represents the difference in weight between the original material and the sum of the weights of the desaturated fabric (corrected for any adhering foreign matter, such as carbonaceous matter) plus moisture (ascertained in Section 11) plus any comminuted surfacing present (ascertained in Section 9, plus the amount recovered from the surface of the desaturated fabric, plus the amount obtained on evaporating and igniting the bituminous extract).

IV. EXAMINATION OF THE EXTRACTED FABRIC.

(*A*) *Woven Cotton Fabrics.*

Woven Cotton Fabrics.

18. Woven cotton fabrics shall be tested in accordance with Sections 6 to 11, inclusive, of the Standard General Methods for Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

(*B*) *Felted Fabrics.*

Weight.

19. The weight in pounds per 480 sq. ft. of the desaturated felt (corrected for any carbonaceous matter present) for each specimen examined, shall be calculated separately from the formulas:

$$\text{“Number”} = \frac{\text{Weight of specimen in grams}}{\text{Area of specimen in square centimeters}} \times 983$$

or

$$\text{“Number”} = \frac{\text{Weight of specimen in grams}}{\text{Area of specimen in square inches}} \times 152$$

This represents the "number" of the moisture-free felt on the felt makers' scale. The minimum, maximum and average "number" of the felt in its moisture-free state shall be calculated. This may be corrected to the condition in which it actually existed in the material under examination, by adding thereto the percentage of moisture as determined in Section 11.

Ash.

20. A representative sample shall be secured by cutting from each strip of desaturated felt a piece about $\frac{1}{2}$ in. in diameter as shown at *I-1*, *I-2*, and *I-3* (Fig. 1). About 25 g. selected at random from all the specimens sampled in this manner shall be accurately weighed, and incinerated in a weighed porcelain or quartz crucible either over an

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[1] 1921 Book of A.S.T.M. Standards.

open flame or in a muffle, until all the carbon is consumed. A few drops of ammonium carbonate solution shall be added, the sample ignited gently, and weighed. The percentage of ash shall be calculated on the basis of the moisture-free felt.

NOTE.—As a referee method, or in case greater accuracy is desired, the three portions taken from each specimen roll shall be weighed and ignited separately. The minimum, maximum and average of ash present shall be calculated on the basis of the moisture-free felt.

Fibers Present.

21. (*a*) A representative sample shall be secured by cutting from each strip of desaturated felt a piece about ½ in. in diameter as shown at *J-1*, *J-2*, and *J-3* (Fig. 1). The pieces shall be placed in a small beaker, boiled with water and macerated until the fibers are well separated and reduced to a pulp. They shall then be transferred to a stout flask. About 50 g. of glass beads shall be added and the contents of the flask shaken vigorously until the fibers are reduced to a homogeneous mass in a uniform suspension. A small portion of the well-mixed pulp shall be removed with a dropper or pipette and three or four drops shall be rapidly transferred to a microscope slide. Ten such slides shall be prepared, refilling the dropper each time.

(*b*) The drops shall be spread thinly over the microscope slides with a needle so that the fibers will be uniformly distributed and not bunched together. The slides shall then be placed in an air-bath to expel the water, cooled and stained with a drop or two of zinc-chlor-iodide solution.

NOTE—The zinc-chlor-iodide solution may be prepared by dissolving 4 g. of potassium iodide and 0.1 g. of iodine in 12 cc. of water, and then adding 20 g. of zinc chloride and allowing the liquid to stand until all undissolved matter has settled out. This solution must be kept in a dark place and prepared freshly from time to time, as it loses its strength. To test out the stain, a mixture of equal parts of rag filter paper, bleached soda pulp and bleacher sulfite pulp, shall be prepared, and tested as directed. If the stain is of the correct strength, the rag fibers will show a wine-red color, the soda pulp a dark purple color, due to the thicker and more opaque fiber walls, and the sulfite pulp a light purple color due to the thinner fiber walls. If the purple color is more of a violet, then too much iodine is present and more water or zinc chloride should be added. Zinc chloride intensifies the purple color, iodine the wine-red and yellow colors, and water serves to weaken the color that predominates.

(*c*) The stained pulp shall be covered with round or square pieces of thin glass approximately ½ in. in diameter, and the excess of staining solution shall be removed from the edges with a piece of filter paper.

(*d*) The slides shall be examined under a microscope having a magnification of about 100 diameters.

(*e*) The various fibers are colored as follows:

Rag Fibers.—

Cotton and linen fibers—stained wine-red.
Wool fibers—unstained by the solution.
Jute and manila fibers—stained yellowish-brown.

Paper, Wood, Straw, etc., Fibers.—

Mechanical wood pulp, sawdust, straw, bark, etc.—stained lemon yellow.
Chemical wood pulp, (sulfite or soda), stained grayish purple to purple.

(*f*) The eye may be trained to the colors and shapes of the various fibers by examining specimens of known composition under similar conditions. In this way the fibers may readily be identified in unknown mixtures by:

(1) The colors to which they are stained.
(2) Their characteristic sizes and shapes.

(*g*) The fibers shall be counted in each field, disregarding any short ends projecting into the field or small fragments interspersed throughout it. Small particles of sizing, clay, or mineral matter should likewise be disregarded.

(*h*) Five fields shall be selected at random on each slide and the fibers counted in each. A total of 50 fields will be thus examined. The aggregate number of each variety of fiber counted in all the fields shall be calculated in percentage.

(*i*) The fibers present shall be reported in percentage *based on their count*, and should be generally accurate to within 5 per cent, depending upon the skill of the operator.

NOTE 1.—As the dimensions and specific gravity of the fibers have not been taken into consideration, the method is obviously inaccurate to this extent. Spence and Krauss[1] have worked out a set of factors for expressing the results into terms of weight, taking into consideration the dimensions and specific gravity of the fibers. This method is recommended, although it is somewhat slow and laborious.

NOTE 2.—As a referee method, or in case greater accuracy is desired, a separate microscope test shall be run on the three portions taken from each specimen roll. The minimum, maximum and average percentage of the various fibers present shall then be calculated.

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[1] *Paper*, Vol. XX, No. 11, p. 11, May 23, 1917.

TENTATIVE METHODS OF TESTING BITUMINOUS MASTICS, GROUTS AND LIKE MIXTURES.[1]

Serial Designation: D 147 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. DEFINITIONS.

Scope.

1. These methods apply to bituminous mastics, grouts and like mixtures, which may be classified and defined as follows:

Bituminous Grouts.—Mixtures of bituminous binder and a mineral aggregate as coarse as sand which become sufficiently liquid when heated to approximately 300° F. to flow into place without mechanical manipulation, and congeal to a dense mass.

Bituminous Mastics.—Mixtures of bituminous binder and mineral aggregate composed of 10 to 15 per cent of bitumen and graded mineral particles ranging in size from dust to $\frac{1}{4}$ in., and which upon being heated to approximately 400° F. may be poured into place, requiring trowelling for compression into a dense mass, or pulverized natural bituminous rock and additional bitumen.

Mastic Cake.—Mixtures of bitumen and fine mineral aggregate containing from 12 to 16 per cent of bitumen by weight, 25 to 50 per cent of 200-mesh calcareous or siliceous dust which will pass a 200-mesh sieve, and sand.

II. PREPARATION OF SAMPLES.

Preparation of Samples.

2. (*a*) Bituminous grouts shall be heated in an oven or on a hot plate in a pan or other suitable container at the lowest possible temperature to prevent overheating and volatilization, and when sufficiently fluid, shall be thoroughly stirred to insure a uniform sample, whereupon 10 to 30 g. shall be taken for analysis.

(*b*) Bituminous mastics or mastic cake shall be warmed on a hot plate or in a hot oven until soft enought to be broken up or stirred so that a representative sample for analysis may be taken. The amount taken for analysis will depend upon the amount of coarse gravel or stone in the mixture. The larger the gravel or stone, the larger will be the sample required for accuracy. The size of samples to be taken shall be as follows: Where all particles pass a 10-mesh sieve, 10 to 30 g.; where 25 per cent of the aggregate is retained on a 10-mesh sieve, 50 g.; where 50 per cent of the aggregate is retanied on a 10-mesh sieve, 100 g.; and where 75 per cent of the aggregate is retained on a 10-mesh sieve, 200 g.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

NOTE.—Where the properties of the extracted bituminous matter are to be determined, it may be necessary in certain cases to take as much as 500 g. for analysis.

III. APPARATUS.

(*A*) *For Analysis of 10 to 30-g. Samples.*

Apparatus, 10 to 30-g. Samples.

3. In cases where a 10 to 30-g. sample is sufficient, the analysis shall be carried out by means of the glass extractor described in Section 8 of the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 22 T) of the American Society for Testing Materials.[1]

(*B*) *For Analysis of 50 to 500-g. Samples.*

Apparatus, 50 to 500-g. Samples.

4. The apparatus for analysis of samples containing coarser aggregate shall be the large extractor shown in Fig. 1, consisting of a large brass cylinder, through the bottom of which projects a 16-candle-power incandescent carbon filament bulb to supply heat to the extraction apparatus proper, which is held in the upper portion of the cylinder. This apparatus is composed of a cylindrical brass vessel for holding the solvent, a cylindrical wire basket made of 80-mesh wire cloth suspended in the cylinder, and an inverted conical condenser which serves as a top.

IV. PROCEDURE.

(*A*) *Analysis of 10 to 30-g. Samples.*[2]

Procedure.

5. An ordinary Whatman or S. and S. Filter Thimble shall be dried and weighed. The weighed sample shall be placed in the thimble and 40 to 50 cc. of CS_2 poured over the sample. The thimble containing the sample shall be suspended under the condenser by a fine wire bail. The flask shall be cautiously heated by a steam-bath or electric heater just enough to vaporize the solvent. Cold water is circulated through the condenser. The heat evaporates the carbon disulfide in the flask. This condenses upon the condenser and drops back upon

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[1] See p. 947.

[2] This method and the method for analysis of larger samples are especially adapted for asphalt mastics, grouts and mastic cake. If the binder is coal-tar pitch, the "free carbon" constituent of the binder will remain with the mineral aggregate. The committee has under consideration a possible separate method for analysis of coal-tar mastics.

the sample through which it filters, thus dissolving out the bitumen which collects in the bottom of the flask.

The extraction should be discontinued when the CS_2 drops colorless from the filter. The time of extraction will depend upon the nature of the bitumen and mineral aggregate in the sample and upon the degree of heat applied, the coldness of the water in the condenser and other factors. In some cases extraction may be complete in one hour, in others four or five hours may be necessary.

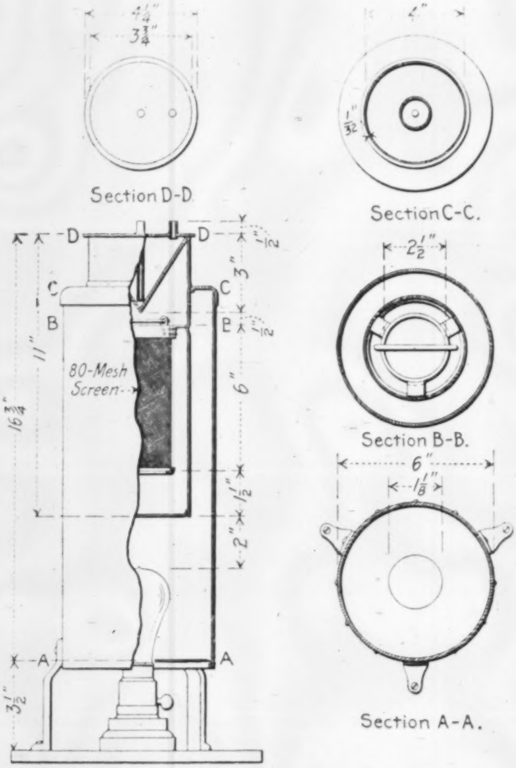

FIG. 1.

When the solvent comes through clear, the filter shall be removed and washed with a fine jet of CS_2 from a washing bottle to wash out any bitumen that may be retained at the top of the paper and to break up any channels that may have been formed by the CS_2 passing through. If the washings show any color, the thimble shall be put back and extraction continued until the solvent again becomes colorless. It shall then be removed, dried carefully, at a low temperature at first to prevent ignition of the absorbed CS_2, and finally to constant weight at 212° F., cooled and weighed.

The solution in the flask shall be rinsed into a weighed porcelain or silica evaporating dish or crucible and the solvent burned off under a hood. The residue shall be ignited over a flame or in a muffle and the ash weighed and the weight added to that of the mineral matter in the filter paper. This is to correct for the fine mineral matter which will be carried through the paper by the solvent. Should there be a considerable amount of ash recovered in this way, and if it is found that the mineral matter is calcium or other carbonate, it shall be recarbonated by repeated treatment with ammonium carbonate solution and finally ignited at a dull red heat. Ordinarily, however, the mineral matter going through the paper will be so small in amount that the difference caused by ignition may be neglected.

The corrected loss in weight on the original sample represents the percentage of bitumen.

The mesh analysis of the mineral aggregate shall be made in accordance with the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material, except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials.[1] The extracted residue shall now be transferred from the thimble to the 200-mesh sieve, the paper being gently rubbed to free adhering particles.

The aggregate on the sieve shall be gently rubbed with the fingers to break up lumps and to free any particles of fine dust that might adhere to larger sand particles. The sieve shall be shaken over a piece of paper from side to side with the right hand, striking it sharply against the palm of the left hand until no appreciable amount of dust comes through the sieve on to the paper. The paper shall be cleared from time to time by raising one side with the left hand and rolling off the siftings, so that it can be seen when the sifting is complete.

The material remaining on the 200-mesh sieve shall be weighed and the amount of 200-mesh material which has passed through shall be determined by difference.

This operation shall be repeated upon the coarser sieves in order and the amount passing each sieve and retained on the next finer recorded as percentage of the original sample.

(*B*) *Analysis of 50 to 500-g. Samples.*

6. A large filter paper, 12 or 13 in. in diameter, shall be fitted inside the wire basket of the extractor by folding once more than in

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[1] 1921 Book of A.S.T.M. Standards.

ordinary filtering, or by wrapping it over a form which fits inside the basket (a cylindrical bottle of proper size makes a good form) and placing it inside the basket.

The basket with contained filter paper shall be dried and weighed. The sample shall be weighed and packed in the filter paper in the basket. Care should be taken not to pack all coarse particles in one place and the fine particles in another but to have them mixed together in uniform proportions.

The sample shall be covered with a disk of felt or wad of absorbent cotton to insure even distribution of the dropping solvent, thus preventing it from forming a channel through the sample. The basket shall be suspended in the extractor and 150 to 200 cc. of CS_2 poured over the felt or cotton. The condenser shall be placed over the top and water circulated through it. Current shall be started through the electric lamp underneath the extractor and the extraction carried on exactly as in the smaller glass extractor, but on a larger scale. The time for extraction will vary from 3 to 12 or more hours, depending upon the nature of the sample.

To determine when extraction is complete, the condenser shall be raised and the basket lifted out to observe if drippings are clear. One or two drops caught upon white filter paper should leave but a light stain.

The drying and weighing of the basket, burning off of the solution for correction, and the sifting of the mineral aggregate shall be carried on exactly as in the case of the smaller sample as described in Section 5, except that in sifting mineral aggregates containing coarse stone, it is well to remove the stone by putting the mineral aggregate first through a 10-mesh sieve, as the large stone would injure the 200-mesh sieve.

The stone removed by the 10-mesh sieve may be screened through $\frac{1}{4}$-in., $\frac{1}{2}$-in., and coarser screens in order, as described in the Standard Method of Mechanical Analysis of Broken Stone or Broken Slag, except Aggregates used in Cement Concrete (Serial Designation: D 18) of the American Society for Testing Materials[1] and the fine material passing the 10-mesh sieve through 200-mesh and coarser sieves in order, all amounts passing any one screen or sieve and retained on the next finer one being reported as percentage of the original sample.

Thus the ingredients of the mixture may be roughly separated by the use of the proper sized sieves, and examined for physical and chemical characteristics.

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[1] 1921 Book of A.S.T.M. Standards.

NOTE.—The siftings passing the 200-mesh sieve will consist largely of the dust or pulverized rock used in the mixture. The material between the 100-mesh and 10 mesh will consist largely of the sand used in the mixture, with any particles of fine crushed stone within these limits that existed in the original materials. Gravel or broken stone as a rule will be larger than 10 or 8 mesh.

Carbon tetrachloride, benzol, or chloroform may be used instead of carbon disulfide, with the only difference that in the case of non-inflammable solvents, the solvent will have to be evaporated from the solution of bitumen to determine the ash for correction instead of burning off directly. When the solvent is expelled, the bitumen can be ignited for ash.

(C) *Solubility of Aggregate in Hydrochloric Acid.*

7. Where the mastic is to be used for acid-proof floors, tank linings, etc., pulverized silica and other materials insoluble in acid are used in preparing the mixture. The most important chemical property, therefore, is solubility or insolubility in mineral acids. This determination may be carried out in the following manner:

About 2.5 g. of the dust, or of the coarser material, or stone which has been previously pulverized in a mortar shall be dried to constant weight at 325° F. The loss will represent any moisture that may have been retained in the material as well as any absorbed solvent that may not have been expelled while drying the sample after extraction.

A 1-g. sample of the dried material shall be placed in a 250-cc. beaker, covered with a watch glass and 10 cc. of concentrated c. p. hydrochloric acid added, diluted with 50 cc. of distilled water. Any lumps shall be broken up by means of a glass stirring rod. Any effervescence which may occur shall be noted. If considerable effervescing takes place, the sample may be said to be carbonate. If all the sample, or practically all, dissolves, the determination need not be carried farther. If apparently insoluble, it shall be heated carefully, brought to boiling for 15 minutes and filtered through a tared Gooch filter, washing the insoluble residue with hot water. It shall be ignited and weighed and the loss reported as the percentage soluble in hydrochloric acid.

TENTATIVE METHOD OF SAMPLING BITUMINOUS MATERIALS SHIPPED IN BARRELS OR DRUMS.[1]

Serial Designation: D 148 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1922.

Scope. 1. This method is intended for use in sampling asphalt or coal-tar pitch, shipped in barrels or drums, for use in damp-proofing and waterproofing.

Number of Samples. 2. From each shipment or portion thereof, representing asphalt or coal-tar pitch of the same grade, a number of packages shall be selected at random equivalent to the cube root of the total number of packages in the lot. If the cube root as calculated proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

Packages in Shipment.	Packages Selected.	Packages in Shipment.	Packages Selected.
2 to 8	2	217 to 343	7
9 to 27	3	344 to 512	8
28 to 64	4	513 to 729	9
65 to 125	5	730 to 1000	10
126 to 216	6	1001 to 1331	11

Sampling. 3. By means of an augur, or brace and $\frac{3}{4}$-in. bit, or other suitable means, a $\frac{1}{4}$ to $\frac{1}{2}$-lb. sample shall be removed from the center and from two points at least 3 in. from the top, bottom and side of each package selected, care being taken to avoid contamination with superficial water, wooden slivers, or other foreign matter.

Preparation of Sample. 4. (*a*) The three samples taken from each package selected shall be melted together over a hot plate, or an oil or paraffin bath, or in an air-bath at a temperature not exceeding 250° F. (121.1° C.). The source of heat shall then be removed, whereupon the well-mixed asphalt or coal-tar pitch, which shall be free from air bubbles, shall be poured to a depth of not less than 15 mm. ($\frac{5}{8}$-in.) into a container of the form described in Section 2 of the Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials.[1] A separate specimen shall be thus prepared from each package sampled, each of which shall be used for ascertaining the softening point and penetration. The minimum, average and maximum values thus obtained will serve to disclose the uniformity of the shipment, also whether or not it falls within the limits prescribed for these tests.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1923, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

(*b*) The remainder of the material taken from each package, while still melted, shall be poured together and thoroughly stirred, whereupon 1 lb. shall be transferred to a clean receptacle, and the stirring continued until the asphalt or coal-tar pitch congeals. This single specimen shall be used in the case of asphalt for ascertaining the flash point, loss on heating, penetration after heating, ductility and insolubility in carbon disulfide; and in the case of coal-tar pitch, for ascertaining water, specific gravity, softening point, distillation test, ductility and insolubility in carbon disulfide.

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[1] 1921 Book of A.S.T.M. Standards.

TENTATIVE METHODS OF TESTING INSULATING VARNISHES.[1]

Serial Designation: D 115 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1921; Revised, 1922.

Material Covered. 1. These tests are intended for varnishes which are applied by brushing, dipping or spraying, and are primarily for the purpose of providing electrical insulation.

SPECIFIC GRAVITY.

Specific Gravity. 2. The specific gravity shall be measured with a pyknometer, Westphal balance or with a hydrometer so graduated that the specific gravity can be determined to 0.001. The temperature of the varnish shall be not less than 18° C. (64.4° F.) nor more than 22° C. (71.6° F.) and corrected to 20° C. (68° F.) by applying a correction of 0.0007 per 1° C. (0.0004 per 1° F.).

VISCOSITY.

Viscosity. 3. (*a*) The viscosity shall be determined with a MacMichael, Stormer plastometer or other suitable type of instrument. The short-tube type of efflux viscosimeter usually employed for lubricating oils is not acceptable. The temperature of the varnish shall be 20° C. (68° F.).

(*b*) The report shall include such details as the kind of instrument used, the size of the counterweight if a Stormer instrument is used, or the size of the wire in case the MacMichael instrument is used, etc.

FLASH POINT.

Procedure for Flash Point. 4. The flash point shall be determined in accordance with the Standard Method of Test for Flash Point of Volatile Flammable Liquids

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, 102 River St., Newark, N. J.

(Serial Designation: D 56) of the American Society for Testing Materials.[1]

TIME OF DRYING.

Test Specimen.

5. (*a*) Specimens for this test shall be pieces of thoroughly cleaned, smooth sheet copper or brass about 3 cm. (1.18 in.) wide and 20 cm. (7.88 in.) long and about 0.127 mm. (0.005 in.) thick.

(*b*) The specimens shall be dipped once in the varnish and withdrawn slowly and uniformly (about 15 in. (38 cm.) per min.). The consistency of the varnish shall be first so adjusted by trial that the thickness of the film of varnish on each side of the metal shall be between 0.022 mm. (0.0009 in.) and 0.026 mm. (0.001 in.).

Procedure.

6. (*a*) Specimens of air-drying varnish shall be dried in free air at a room temperature of approximately 20° C. (68° F.).

(*b*) In the case of baking varnishes, six specimens shall be dipped and allowed to drain at a room temperature of approximately 20° C. (68° F.) until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger will not become obliterated by further flow of the material. They are then to be dried in free air in an oven at approximately 100° C. (212° F.). At the end of the first 30 minutes, and again at the end of each 10-minute period thereafter, one specimen shall be taken from the oven and examined.

Time of Drying.

7. The varnish shall be considered dry when a specimen will not stick to itself when folded and pressed together between the thumb and finger at a temperature of approximately 20° C. (68° F.).

DIELECTRIC STRENGTH TEST.

Dielectric Strength Test Specimen.

8. (*a*) Specimens for the dielectric strength test shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which shall be at the consistency prescribed in Section 5 (*b*).

(*b*) Each specimen shall be dipped four times as specified in Section 5 (*b*), once in each direction, in order to give a more uniform thickness of coating. The specimen shall be dried after each dip in the same vertical position in which it was dipped.

(*c*) Specimens of air-drying varnish shall be dried in free air at a room temperature of approximately 20° C. (68° F.) for a period 25 per cent longer than that found in Section 7.

(*d*) Specimens of baking varnish shall be drained and then baked for a period 25 per cent greater than that found in Section 7.

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[1] 1921 Book of A.S.T.M. Standards.

(*e*) The final thickness of the film of varnish on each side of the specimen shall be between 0.089 mm. (0.0035 in.) and 0.102 mm. (0.004 in.).

Procedure. 9. (*a*) The dielectric strength of the two films of varnish shall be determined by applying alternating potential to two circular metal disks, 3 cm. (1.18 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). The potential shall be applied at a low value and gradually raised at a rate such that puncture will occur in about ten to fifteen seconds. Ten such punctures are to be made at various points selected at random on each specimen. In each test the thickness of the films of varnish is to be determined as close to the point of puncture as practicable.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined, and the voltage shall be measured by methods approved by the American Institute of Electrical Engineers.[1]

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 500 volts. The apparatus shall comply with the Standardization Rules of the American Institute of Electrical Engineers.[1]

Dielectric Strength. 10. The volts at puncture, the net thickness of insulation and the volts per mil of net thickness shall be reported for each of the ten tests together with the average maximum amd minimum volts per mil.

WATER ABSORPTION TEST.

Procedure. 11. Specimens similar to those described in Section 8 shall be immersed in water at a room temperature of approximately 20° C. (68° F.) for a period of 24 hours. Upon removal from the water, the surface water shall be wiped off and dielectric strength tests made immediately as described in Section 9.

Dielectric Strength. 12. The volts at puncture, the net thickness of the insulation and the volts per mil of net thickness shall be reported for each of the ten tests, together with the average, maximum and minimum volts per mil.

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[1] **Standards of the American Institute of Electrical Engineers.**

HEAT ENDURANCE TEST.

Test Specimens.

13. For the heat endurance test, specimens shall be prepared as in Section 8. After removing not less than 1.27 cm. (0.5 in.) from one edge of the specimens, the required number of strips shall be cut from the same edge, each 1.9 cm. (0.75 in.) in width.

Procedure

14. (*a*) After setting as shown by the test indicated in Section 6 (*b*), the strips referred to in Section 13 shall be placed in a uniformly heated oven in which the temperature is maintained at 100° C. (212° F.) within ± 5° C. (9° F.). A strip shall be removed at the end of 1, 2, 4, 8 and 24 hours respectively and every 24 hours thereafter. These, together with the initial strip, shall be tested as follows at a room temperature of approximately 20° C. (68° F.).

(*b*) Each specimen shall be bent through 180 deg. over rods of 0.64 cm. ($\frac{1}{4}$ in.), 0.48 cm. ($\frac{3}{16}$ in.) and 0.32 cm. ($\frac{1}{8}$ in.) diameters respectively, beginning with the largest and using each time a part of the specimen which has not been previously bent. The diameter of the rod at which the first crack in the insulation occurs shall be noted and reported.

ACID AND ALKALI PROOF TEST.

Test Specimens.

15. The specimens to be used for the test for acid and alkali proofness shall be brass rods 1.5 cm. (0.59 in.) in diameter, 15 cm. (5.90 in.) long and carefully rounded at one end to a radius of 0.75 cm. (0.295 in.). These specimens shall be dipped three times into the varnish, leaving exposed about 3 cm. (1.18 in.) of the rod at the end opposite the rounded end. Each coat shall be dried 25 per cent longer than the period determined in Section 7. Three specimens each shall be prepared for the acid and alkali solutions.

Procedure.

16. (*a*) The three specimens shall be suspended in the acid or alkali whose effect it is desired to determine to within 3 cm. (1.18 in.) of the end of the coated portion of the rod and suitable provision made for detecting the change in the electrical resistance between the rod and the solution. (Note 1.)

(*b*) It is recommended that these tests be made in 10-per-cent solutions as follows:

Sulfuric acid of sp. gr. 1.069 at 60° F. (15.5° C.) or nitric acid of sp. gr. 1.056 at 60° F. (15.5°) C.) or hydrochloric acid of sp. gr. 1.050 at 60° F. (15.5° C.) and sodium hydroxide of sp. gr. 1.115 at 60° F. (15.5° C.).

(*c*) The temperature of the solution shall be kept at approximately 20° C. (68° F.).

NOTE 1. A simple method is to connect a voltmeter between each rod in turn and one side of a 110-volt direct current circuit, the other side of the circuit being connected to the solution through any piece of suitable metal suspended in the solution. The resistance will be inversely proportional to the deflection of the voltmeter pointer, that is, the smaller the deflection, the greater the resistance. Failure of the material will, therefore, be indicated by a sudden increase in the deflection of the voltmeter pointer.

Acid and Alkali Proofness.

17. The resistance between each rod and the solution shall be measured once per day and the number of days elapsing before breakdown occurs shall be taken as the "proofness" of the varnish.

OIL TEST.

Oil Test Specimen.

18. For the test for the effect of oil, pieces cut from the specimens prepared for the dielectric strength test (Section 8) may be used after they have been punctured and measured.

Procedure.

19. The effect of oil on the varnish shall be determined by immersing the specimens in transformer oil at a temperature of 100° C. (212° F.) for 48 hours and noting the effect on the varnish as indicated, for example, by wiping with a piece of dry white cloth.

TENTATIVE METHOD OF TEST
FOR
MOMENTARY DIELECTRIC STRENGTH OF SHEET INSULATING MATERIALS.[1]

Serial Designation: D 149 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

1. This test is intended to determine the dielectric strength of sheet materials for electrical insulation, under voltage stresses of short duration. It should not be considered as indicating the permanent dielectric strength of the material, as breakdown will take place at a lower voltage when applied for a greater length of time.

I. APPARATUS.

High Voltage Transformer.

2. (*a*) Any well designed, high tension transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1923, to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, 102 River St., Newark, N. J.

(*d*) Some protection is desirable in the high tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high tension terminals, it should not be greater than that which will limit the high tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the standardization rules of the American Institute of Electrical Engineers.

Electrodes.

3. The electrodes shall be of brass or copper and 1 in. (25.4 mm.) thick and 2 in. (50.8 mm.) in diameter. The edges shall be rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.). The contact surfaces shall be flat and polished.

II. TEST SPECIMENS.

Test Specimens.

4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

III. PROCEDURE.

Surrounding Medium.

5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes.

6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen. 7. The electrodes shall be self aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

Application of Voltage. 8. Starting at zero, the testing voltage shall be increased uniformly at such a rate that puncture will take place in from 10 to 15 seconds.

Number of Tests. 9. Ten tests shall be made and the average of these ten puncturing voltages shall be taken as the momentary dielectric strength of the sample.

Thickness. 10. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 11. The report shall include the following:

(*a*) The thickness of the specimen at each puncture.

(*b*) Total volts and volts per mil of thickness at each puncture.

(*c*) The average, maximum and minimum volts at puncture per mil thickness for each sample.

(*d*) The room temperature.

(*e*) The relative humidity, in per cent.

TENTATIVE METHOD OF TEST FOR PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT OF MOLDED ELECTRICAL INSULATING MATERIALS AT RADIO FREQUENCIES.[1]

Serial Designation: D 150 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1922.

1. This method of test is intended to apply to non-vitreous solid electrical insulating materials that are formed in molds by the application of pressure, either with or without heat.

The behavior of material under test at radio frequencies is fundamentally different from that at low frequencies.

In this test the phase difference of the dielectric is determined at a measured frequency by determining the effective resistance (or equivalent series resistance) and capacity of a condenser made up with the material as the dielectric. The dielectric constant is calculated from the measured capacity of such a condenser, and the thickness and area of the dielectric.

The dielectric power loss is proportional to the product of the dielectric constant and the phase difference.

I. APPARATUS.

Generating Circuit.

2. The circuit in which the radio frequency waves are generated is called the generating circuit. The source of radio frequency voltage shall be an electron tube oscillator the frequency of which can be varied over the range desired and which can be coupled loosely to the measuring circuit. It shall furnish sufficient power so that the presence of the measuring circuit will not reduce its output. The output of the oscillator must be very constant, as any variation in voltage will cause a much larger variation in the final results, because of the differential method used. For this reason it is highly desirable to have the

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1923, to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, 102 River St., Newark, N. J.

plate current supplied by a storage battery or other source of very constant power.

Measuring Circuit.

3. The circuit in which the electrical insulating material specimen is placed for test is called the measuring circuit.

This circuit is composed of:

A condenser employing the test specimen as the dielectric and two mercury surfaces as the conducting plates.

A standard condenser of a special design having negligible phase difference or power factor.

One or more special inductance coils.

A low-resistance thermo-element (preferably less than five ohms).

A special double-pole double-throw switch equipped with mercury wells.

A set of resistor links having direct current resistance values ranging from negligible to about 40 ohms.

A sensitive low-resistance wall galvanometer of the deflecting mirror type or other suitable type of indicating instrument.

The arrangement of the apparatus in the measuring circuit is shown in Fig. 6 of the Appendix.

Frequency Meter.

4. The instrument used to measure the frequency of oscillation of the current in the generating circuit is called a frequency meter or wave meter. This instrument may be of any commercial design covering the wave-frequency range of about 85.7 to 1500 kilocycles per second (corresponding to wave lengths of 3500 to 200 meters) and capable of calibration accurate to within 1 per cent over the wave-frequency range used.

II. TEST SPECIMEN.

Test Specimen.

5. The test specimen shall be a disk having the dimensions shown in Fig. 13 of the Appendix. A raised rim about the circumference is provided to hold a layer of mercury to form the upper plate when the specimen is used as a condenser.

III. PROCEDURE.

(*A*) *Phase Difference* (*power factor*).

Method.

6. (*a*) The phase difference (power factor) of two specimens shall be measured by the resistance-variation method[1] in the condition received at normal room temperature of about 20° C. (68° F.) and at 5 radio-frequencies between 98 and 1200 kilocycles per second (3050 to 250 meters) each.

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[1] The principles of the resistance-variation method of measuring phase difference and dielectric constant are given in Bureau of Standards *Circular No. 74*, pp. 180–193.

(*b*) The phase difference (power factor) of two specimens shall be measured by the same method and at radio frequencies within the same limits as mentioned in Paragraph (*a*) after the specimens have been immersed in water at a temperature of about 20° C. (68° F.) for 48 hours. The circumference of the specimen shall have been protected from the action of the water by dipping it in melted paraffin to a depth of 10 mm. (0.394 in.) and rotating it. After removing the specimen from the water, the surface water shall be wiped off with a clean, absorbent cloth, being careful not to handle the paraffined edge, and then allowed to stand in the room away from drafts and direct sunlight for five minutes before floating on the mercury surface preparatory to making the measurements.

Electrodes. 7. The specimen shall be floated on mercury in a glass dish on an insulating support levelled by means of levelling screws. Sufficient mercury shall be poured on the top of the specimen to cover the upper surface.

Procedure. 8. The details of the method of testing for phase difference are given in the Appendix.

Calculations. 9. The values of phase difference in degrees shall be calculated from the formula:

$$\text{Phase difference in degrees, } \Psi^\circ = 3.60\ RCf \times 10^{-7}$$

where f = frequency in kilocycles per second;
R = measured resistance of specimen condenser in ohms;
C = measured capacity of specimen in micromicrofarads;

or

$$\text{Phase difference in degrees, } \Psi^\circ = 0.1079\ \frac{RC}{\lambda}$$

where R and C are the same as above and λ = the wave length expressed in meters.

(*B*) *Dielectric Constant.*

Method. 10. The capacity of a condenser in which the specimen is the dielectric shall be determined by comparison with a standard variable air condenser under the conditions prescribed for phase difference measurements in Sections 6 (*a*) and 6 (*b*) with the specimen arranged as in Section 7.

Procedure. 11. The details of the method of determining capacity are given in the Appendix.

Calculations. 12. The dielectric constant shall be calculated from the formula:

$$\text{Dielectric constant } K = \frac{CT}{0.0885\ S}$$

where C = the capacitance of the specimen in micromicrofarads;
T = the average thickness of the specimen expressed in centimeters;
S = the area of the upper mercury surface expressed in square centimeters;

or

$$K = \frac{CT}{0.224\,S}$$

where C = the capacitance of the specimen in micromicrofarads;
T = the average thickness of the specimen expressed in inches;
S = the area of the upper mercury surface expressed in square inches.

IV. REPORT.

13. The report shall include the following: **Report.**

(*a*) The description of the material: *i. e.*, filler, binder, grade, color and average thickness.

(*b*) Room temperature and relative humidity.

(*c*) A curve for each specimen, showing phase difference (power factor) and dielectric constant plotted as ordinate values, and wave frequencies (wave lengths) as abscissa values for the specimen as received and after immersion in water for 48 hours. Each curve sheet will, therefore, show two phase difference and two dielectric constant curves.

(*d*) The phase difference and dielectric constant of each specimen at wave frequencies of 100 and 1000 kilocycles per second (3000 and 300 meters) as read from the curves for each of the two conditions and the average phase difference and dielectric constant and their product at these same frequencies.

APPENDIX.

DETAILS OF RESISTANCE-VARIATION METHOD OF MEASUREMENT OF PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT.

Introduction.—A test specimen for the measurement of phase difference and dielectric constant at radio frequencies consists of a piece of insulating material placed between metal plates, the whole constituting an electric condenser. It is quite convenient and satisfactory to use mercury as the metal for the condenser plates. The specimen of molded insulating material may be floated on mercury and a pool of mercury formed on top of the specimen, confined by the raised rim about the edge of the test specimen.

The phase difference of an electrical insulating material is

$$\psi = 90^\circ - \theta$$

where θ is the phase angle between the current flowing and the voltage across a condenser which has the space between its conducting plates filled with the insulating material. The voltage E (Fig. 1) across the condenser may be considered to be made up of a voltage $\frac{I}{\omega C}$ acting on the capacity and a voltage $R\ I$ acting on a resistance in series with the capacity. Thus, the condenser is, for the purpose of measurement, considered as equivalent to a pure capacity C with a resistance R in series with it (Fig. 2). This resistance is called "effective resistance" or "equivalent resistance" of the condenser, sometimes shortened to simply "resistance." This resistance is quite distinct from the direct-current or leakage resistance of the condenser.

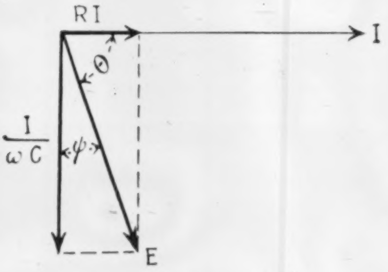

FIG. 1.—Vector Diagram.

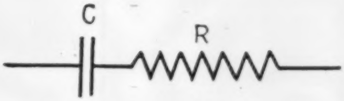

FIG. 2.—Condenser Circuit.

The phase difference ψ may be calculated from the effective resistance and other quantities as follows: From Fig. 1.

$$\tan \psi = \frac{R\ I}{\frac{I}{\omega\ C}} = R\ \omega\ C$$

where $\omega = 2\pi$ times the frequency of the current. Since for small angles $\tan\psi = \psi$, therefore

$$\psi = R\,\omega\,C.$$

The phase difference ψ is known if R, ω and C are known. The phase difference measurement thus involves a determination of three separate quantities. The formula $\psi = R\omega C$ is correct for ψ in radians, R in ohms and C in farads. With

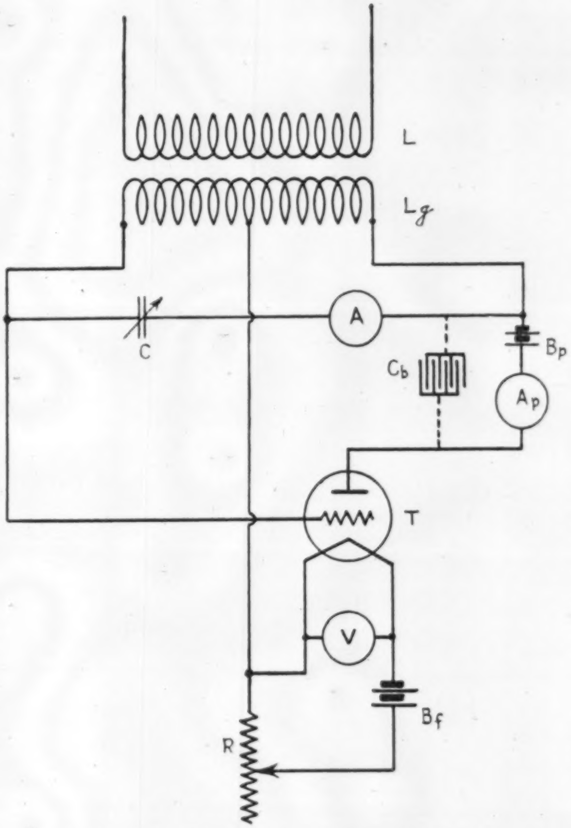

FIG. 3.—Radio-Frequency Generating Circuit.

the wave length in meters (λ_m) in the formula instead of ω, ψ in degrees instead of radians, R in ohms, and C in micromicrofarads instead of farads,

$$\psi^\circ = 0.1079\,\frac{R\,C}{\lambda_m}$$

The three quantities involved in the phase difference are measured with radio frequency currents. The current of a radio frequency is caused to flow in a circuit containing the condenser made up from the insulating material under test. The equivalent resistance (R) is determined by the resistance-variation method and the capacity is measured by comparison with a standard variable air condenser. The determination of the equivalent resistance is the most important and difficult part of the measurement. The wave frequency or wave length (λ) is measured by a wave-meter placed near the generating circuit.

From the measurement of the capacity C of the test specimen, the value of the dielectric constant of the insulating material is easily obtained. The average thickness T of the dielectric and the area S of the upper mercury surface plate are measured. The dielectric constant is

$$K = \frac{C\ T}{0.0885\ S}$$

where C is expressed in micromicrofarads, T in centimeters and S in square centimeters.

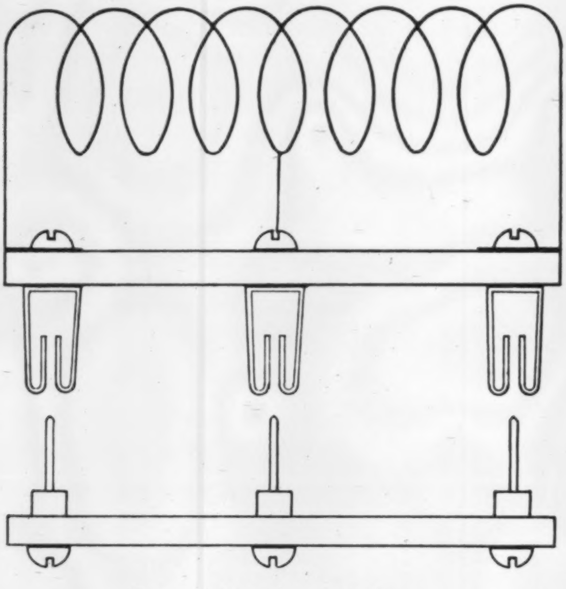

FIG. 4.—Secondary Inductance.

Circuits.—The measurement of phase difference and dielectric constant at radio frequencies requires a generating circuit and a suitable measuring circuit.

The generating circuit is shown schematically in Fig. 3. The inductance coil L_g is any one of a series of detachable tubular single layer inductors arranged somewhat as shown in Fig. 4. For the tests outlined in these specifications, it is probable that no more than five tubular inductors will be required. The smaller inductor may be made by winding 13 turns of wire on a 3½-in. tube with 6 turns on either side of the middle clip. The larger inductor may be made by winding 112 turns of wire on a 6¾-in. tube, 32 turns on either side of the middle clip and 24 turns outside of both outside clips. The other three inductors may be made to cover the gap between these two extremes.

The variable air condenser C may be of any suitable commercial shielded type having a maximum capacity of about 0.003 microfarads (3000 micromicrofarads). The ammeter A is of the hot wire type having a range of 0 to 1 ampere. The by-pass condenser C_b may be any type of fixed condenser capable of withstanding 500 volts (direct current).

The plate battery B_p may be a 100 to 300-volt storage battery of the lead-acid type having an ampere capacity of about 0.2 ampere at the 8-hour discharge rate. Fig. 5 shows a 100-volt battery of this type with the supports fixed for stacking the batteries in an upright position. A lead couple and jar are also shown separately in this figure.

The ammeter A_p may be any type of direct-current instrument having a range of 0 to 50 milliamperes. The three-electrode electron tube T may be any of the so-called power tubes rated at 5 watts or over. The voltmeter V may be any type of direct-current instrument having a range suited to the type of electron tube used. The filament battery B_f should be of the lead-acid type whose voltage and ampere-hour capacity will be determined by the type of electron tube selected. The ampere carrying capacity and the resistance of the rheostat R would also be dependent on the type of tube selected.

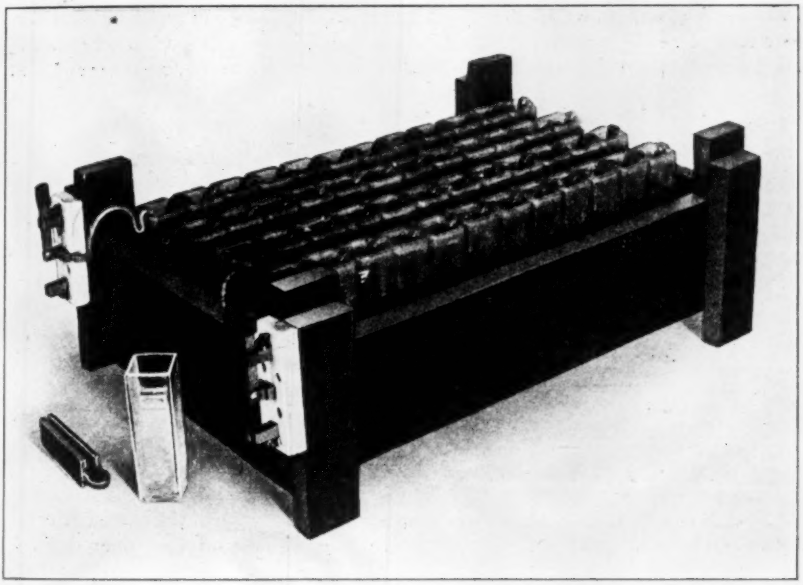

FIG. 5.—Storage Battery.

The measuring circuit is shown schematically in Fig. 6. The standard variable air condenser C_s may be of the Bureau of Standards standard type having a maximum capacity of not to exceed 0.001 microfarads (1000 micro-microfarads). Fig. 7 shows the general construction of this type of condenser. This condenser is described more fully in *Circular No. 74* of the Bureau of Standards, "Radio Instruments and Measurements," Section 32. The special switch with mercury wells, together with a non-inductive resistor are shown in Fig. 8. The special switch is constructed throughout of insulating material except the leads and wells which are of copper. The two upright standards of the switch are Pyrex glass rods about 1 cm. in diameter, while the supports which hold the six copper wells and leads are of Pyrex glass tubing. The copper wells are swaged to the copper leads and no solder used. The non-inductive resistor is made from a piece of glass tubing, two corks, two pieces of about No. 14 copper wire bent to form an L and a piece of small-diameter high-resistance wire. Several of these resistors are required, but in all cases the distance between the spurs should be the same, because the resistors must fit into the mercury wells, as shown in the switch (Fig. 8). Each of these units has a different value of resistance made so by varying either the length or the diameter of the resistance wire or both.

The condenser C_x is made by floating the molded test specimen on mercury and pouring mercury on the upper surface until it is filled to the molded flange. The mercury bath on which the specimen rests is contained in a glass dish which rests on a piece of insulating material which in turn is supported by some sort of a levelling device. Fig. 9 shows the method of floating the specimen except that in this case a rectangular specimen is shown without a flange of the same material. A two-piece rectangular copper mercury retainer is used on the upper surface.

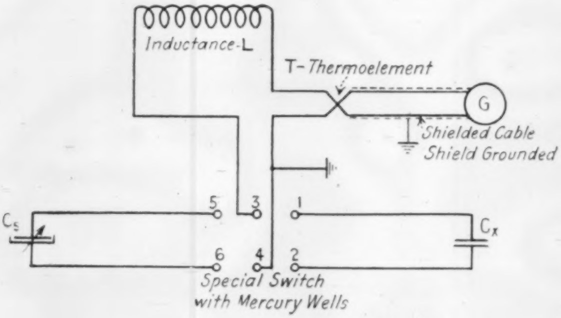

FIG. 6.—Measuring Circuit.

The standard inductor L, Fig. 6, may be of the type shown in Fig. 10, except that only standard binding posts will be required for connections. This inductor must be of some design having a comparatively low resistance so that the coil resistance will not be a large proportion of the combined equivalent resistance of the circuit made up of inductor L and the specimen condenser C_x. To cover the wave frequencies (wave lengths) named in these specifications, it would be desirable to have at least five inductors having inductance values of about 0.1, 0.5, 1, 2, and 3 millihenries.

The thermo-element T is of the crossed-wire type shown in Fig. 11. For this purpose the thermo-element base might better be equipped with four binding posts than with two binding posts and two clips. A cylindrical cap fits into the circular groove cut in the base and is held in place by a cap nut which screws on to the small brass bolt shown attached to the base. The wires used on this type of thermo-element may be of steel and "constantan" or "advance" about 0.02 mm. in diameter (see Bureau of Standards Radio Laboratory Report cR251-2a). The resistance of the thermo-element should be from 3 to 5 ohms. A shielded cable connecting the thermo-element T to the galvanometer G may be standard lead-sheathed duplex cable.

The galvanometer G is a sensitive low-resistance wall galvanometer of the deflecting mirror type whose deflections within reasonable limits are proportional to the square of the current. A Leeds & Northrup No. 2285 high-sensitivity galvanometer with an external damping resistance of about 5 ohms, period about 2 seconds and concave mirror for about one meter focal distance has been found satisfactory.

Fig. 12 shows the complete apparatus as assembled in the Radio Laboratory of the Bureau of Standards. For more exact measurements the complete apparatus itself is housed in a small section of the room and completely surrounded with a fine mesh wire such as window screening. The purpose of this shielding is to insure the accuracy of measurement by shielding out the influence of outside radio-frequency generators. This view shows the wavemeter mounted on a tall stand, a rather complicated radio-frequency generator, a rack of 100-volt storage batteries, the bottle of distilled water for use with the batteries, the galvanometer rack showing the scale, lamp and galvanometer, the test specimen floated ready for measurement, the special skeleton switch, the standard inductor, the standard condenser and a box of non-inductive resistors. In addition, there will be observed a series of parallel wires between the generating circuit and the measuring circuit and also between the measuring circuit and the place occupied by the operator. The parallel wires between the generating circuit and the measuring circuit are all soldered together at the end nearest the operator (the left-hand end as shown), and left separate at the other end. The wire which connects all the parallel screening wires is then attached to a ground connection. The parallel wires between the measuring circuit and the operator are unattached at either end but all attached in the middle. This middle connector is also attached to the ground connection The upper half of the shield between the operator and the measuring circuit is hinged to make it more easy to change the apparatus. It will be noticed that two panels of the over-all wire-netting screen have been removed in the photograph. The third

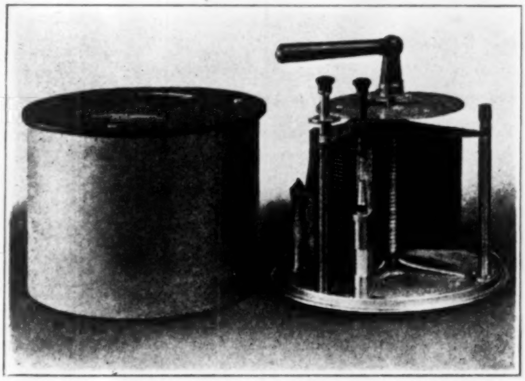

FIG. 7.—Standard Variable Air Condenser.

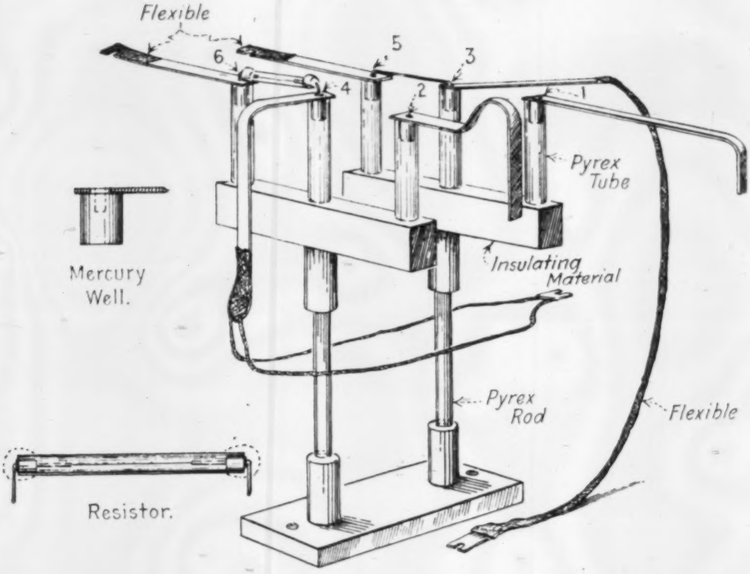
Flexible
6
5
3
4
2
1
Pyrex Tube
Mercury Well.
Insulating Material
Pyrex Rod
Flexible
Resistor.

FIG. 8.—Special Switch.

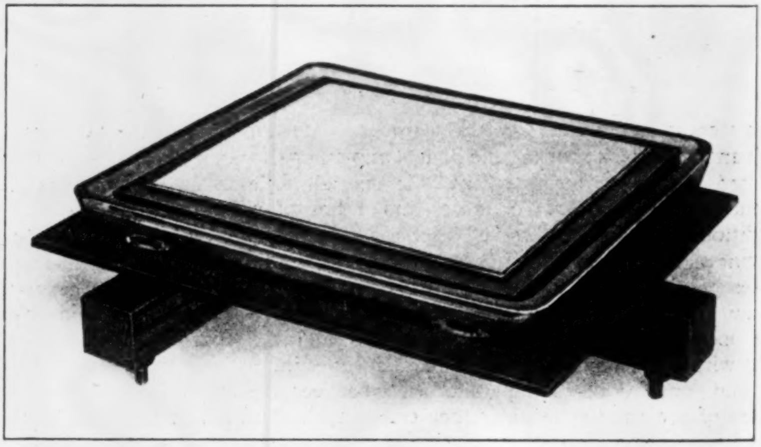

FIG. 9.—Test Specimen Floating on Mercury.

panel at the extreme right front of the photograph is hinged to form a door. This door permits the operator to arrange the test specimen in the mercury bath.

Method of Measurement.—Assume that the 13-turn inductor L_g is in position as shown in Fig. 3 and the other parts of the generating circuit are in readiness and generating radio-frequency current. Bring the generating circuit near to the measuring circuit with the shield of parallel wires between them as shown in Fig. 12. Put the 0.05-millihenry standard inductor L (Fig. 6) in position and insert heavy copper links between wells 1 and 3 and between 2 and 4. Write the value of the inductance L in Space No. 1 of the data sheet, Table I. Tune the generating circuit to the measuring circuit by varying the setting of the condenser C (Fig. 3), resonance being determined by the maximum deflection of the galvanometer G (Fig. 6). It is essential that this tuning be done carefully. Change the coupling between L_g and L until the maximum deflection at resonance is about 40 cm. if a 50-cm. scale is used. Leave the generating circuit untouched and determine the wave frequency (wave length) emitted by the generating circuit by means of a frequency meter (wave meter). Record the wave-meter setting in Space No. 2, Table I. Remove the wave meter. Remove the copper link on the grounded side (that is between wells 2 and 4) and read the zero error of the galvanometer and record the value in Column No. 1 of the data sheet. Reinsert the copper link and record the maximum deflection in Column No. 2. Record the resistance of the heavy copper link as 0 in Column No. 5. Remove the copper link spanning wells 2 and 4 and read the zero deflection of

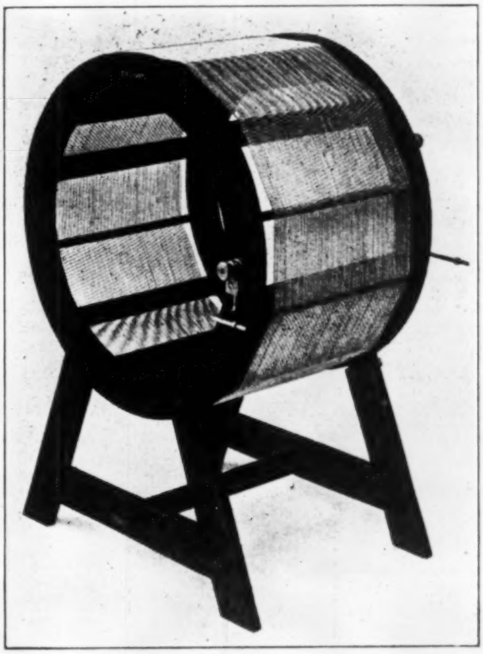

FIG. 10.—Standard Inductor.

the galvanometer. Insert this as the second entry in Column No. 1. Pick out a non-inductive resistor of such resistance that it will cut the galvanometer deflection to about half the maximum value and insert between wells 2 and 4 to replace the copper link. Record the galvanometer deflection as a second entry in Column No. 2 and the ohmic resistance of the resistor as a second entry in Column No. 5. Assuming the copper link to be *A* and three non-inductive resistors of increasing resistance values to be *B*, *C*, and *D*, insert the several links (*A*, *B*, *C*, and *D*) on the grounded side of the switch between wells 2 and 4 in the order *AB*, *AC*, *AD*, *AC*, *AB*. Record each zero error and maxi-

TABLE I.—SAMPLE OF RECORD OF TEST.

Date of Test,.................... Specimen No.,.................... Test No.,....................
Specimen Submitted by.................... Number Submitted,.................... Date,....................
Filler,.................... Binder,.................... Grade,.................... Color,....................
Dry Bulb,........° C........° F. Wet Bulb,........° C........° F. Relative Humidity,........%
Notes..

Average thickness (T)....................(*No. 11*) cm. (*No. 11*) in.
Standard Inductance, (*No. 1*) mh.
Setting of { Wavemeter, (*No. 2*) deg.
Setting of { Stand. Cond. No., (*No. 4*), (*No. 3*) deg.
Upper plate area (S)....................(*No. 12*) cm.^{2} (*No. 12*) in.^{2}
Wave Freq., *kc*/sec., (*No. 5*) f.
Wave Length, (*No. 6*) Meters.
Specimen Capacity, (*No. 7*) $\mu\mu f$.
Phase Difference, Ψ° of { Specimen, (*No. 8*) deg.
Phase Difference, Ψ° of { Circuit, (*No. 9*) deg.
Power factor of Specimen, (*No. 10*) %.
Dielectric Constant, $K=$ (*No. 13*).
Phase difference × Dielectric Constant, $\Psi^\circ \times K=$ (*No. 14*).

Galvanometer.				Resistance Inserted, R_1	$\sqrt[2]{\frac{d_o}{d_1}}-1$	Total Equiv. Resistance, R	Equiv. Res. of C_x, R_x
Zero Deflection.	Maximum Deflection.	True Deflection.	Mean Deflection.				
0.30	41.70	41.40	41.40	*A* 0	.....	.....	22.08
0.32	15.00	14.68	14.69	*B* 18.01	0.679	26.53	.....
0.32	41.70	41.38	41.40	*A* 0	.....	.....	.....
0.33	13.67	13.34	13.36	*C* 20.21	0.761	26.56	.....
0.33	41.70	41.37	41.37	*A* 0	.....	.....	.....
0.38	12.81	12.43	12.43	*D* 21.84	0.825	26.48	.....
0.38	41.79	41.41	.....	*A* 0	.....	.....	.....
0.36	13.75	13.39	.....	*C* 20.21	.....	Ave.	.....
0.37	41.77	41.40	.....	*A* 0	.....	.....	.....
0.39	15.09	14.70	.....	*B* 18.01	.....	26.52	.....
0.49	41.71	41.22	41.23	*A* 0	.....	.....	.....
0.52	17.35	16.83	16.84	*B* 2.51	0.565	4.44	.....
0.50	41.74	41.24	41.24	*A* 0	.....	.....	.....
0.52	14.91	14.39	14.40	*C* 3.08	0.692	4.45	.....
0.50	41.77	41.27	41.27	*A* 0	.....	.....	.....
0.52	11.42	10.90	10.90	*D* 4.20	0.947	4.43	.....
0.53	41.78	41.25	.....	*A* 0	.....	.....	.....
0.53	14.93	14.40	.....	*C* 3.08	.....	Ave.	.....
0.53	41.77	41.24	.....	*A* 0	.....	.....	.....
0.55	17.39	16.84	.....	*B* 2.51	.....	4.44	.....

mum deflection in the proper place in Columns Nos. 1 and 2 and the value of resistance inserted in the circuit in Column No. 5. Remove the links from the wells 1 to 3 and 2 to 4 and insert copper links between 3 and 5 and between 4 and 6. Move the generating circuit about 50 cm. away from the standard inductor *L*, being careful not to change the setting of any of the variables in the generating circuit. Check the wave frequency of the generating circuit. Tune the measuring circuit (composed of the standard condenser C_s, standard inductor *L*, the thermo-element *T* and the galvanometer *G*) to the generating circuit by varying the setting of the standard condenser C_s. Change the coupling between L_g and *L* to give about 40 cm. galvanometer deflection on the 50-cm. scale. Tune the measuring circuit very carefully but do not vary any controls on the generating circuit. Read the setting of the standard condenser C_s and record in Space No. 3. If more than one standard condenser is available in the laboratory, record the number of the condenser used in Space No. 4 for the purpose of identification. Remove the copper link from between wells 4 to 6, read the galvanometer zero deflection and record the value in the first column of the data sheet (see 0.049, Column

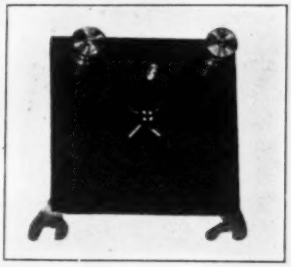

FIG. 11.—Thermo-element.

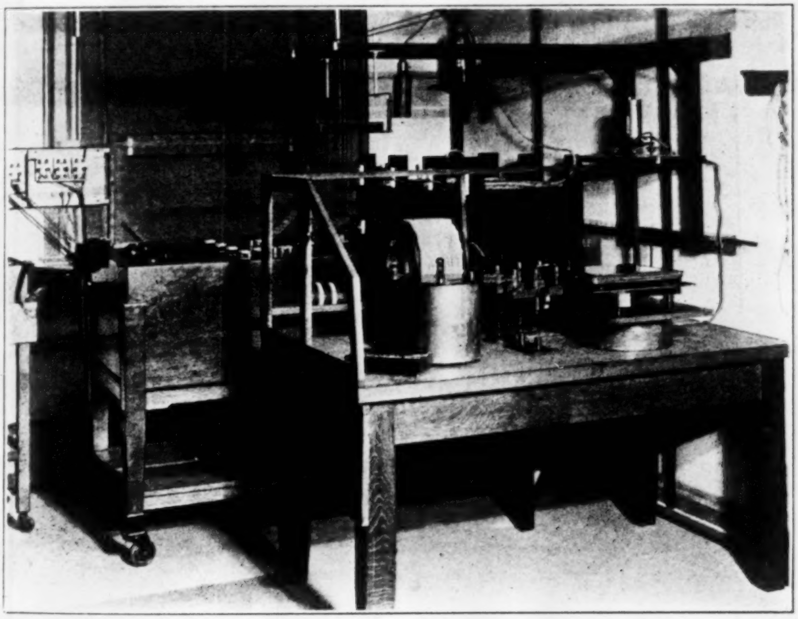

FIG. 12.—Complete Apparatus as Installed in Radio Laboratory, Bureau of Standards.

No. 1). Reinsert the copper link and read the maximum galvanometer deflection, record the numerical value in Column No. 2. Proceed in this manner, as above described, inserting resistors in the order *AB, AC, AD, AC, AB.*

The data in the body of the data sheet may now be computed. Column No. 3 is obtained by subtracting the zero deflection from the corresponding maximum deflection. Thus 41.70 – 0.30 = 41.40, the true deflection, or 15.00 – 0.32 = 14.68. Column No. 4 is obtained by averaging; that is, the two *A* deflections which precede the two *B* deflections, the two *B* deflections, the two *A* deflections which precede the two *C* deflections and the two *C* deflections are averaged. Thus, the average of 41.40 and 41.40 is 41.40 and of 14.68 and 14.70 is 14.69. As has been stated, phase difference

$$\psi^\circ = 0.1079 \frac{R\,C}{\lambda}$$

The equivalent resistance *R* is computed in three steps and recorded in Column No. 8. By one measurement the equivalent resistance (R_x) of the condenser C_x plus the resistance (R_c) of the remainder of the circuit, including the inductor *L*, is determined. By another, the equivalent resistance (R_s) of the standard condenser C_s and the resistance (R_c) of the remainder of the circuit, including the inductor *L*. Since in each case the remainder of the circuit is the same and the standard condenser C_s is considered to have negligible resistance, the difference of the resistance values will be the equivalent resistance of the specimen condenser C_x. That is, the resistance of the condenser C_x plus the resistance of the circuit is $R_x + \mathrm{R}_c$, while the resistance of the standard condenser C_s plus the resistance of the circuit is $R_s + R_c$. R_s is negligible, so $R_s + R_c$ is equivalent to R_c. $(R_x + R_c) - R_c = R_x$ = the equivalent resistance of C_x.

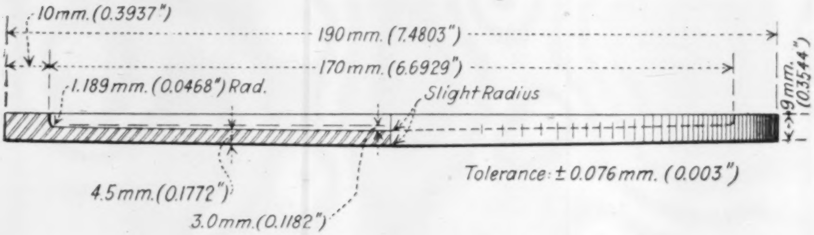

FIG. 13.—Test Specimen.

The combined equivalent resistance of the specimen condenser and its attached circuit is computed first.

$$\text{The equivalent resistance } R = \frac{R_1}{\sqrt[2]{\frac{d_o}{d_1}} - 1}$$

where R_1 = resistance inserted,
d_1 = galvanometer deflection with R_1 inserted,
d_o = galvanometer deflection with no resistance inserted.

The denominator is solved first and its values inserted in Column No. 6, while the values of R are inserted in Column No. 7. Thus, the values in Column No. 6 are

$$\sqrt[2]{\frac{41.40}{14.69}} - 1 = 0.679, \sqrt[2]{\frac{41.40}{13.36}} - 1 = 0.761, \text{ and } \sqrt[2]{\frac{41.37}{12.43}} - 1 = 0.825.$$

The equivalent resistance R (Column No. 7) is obtained by dividing the ohmic resistance of the resistors B, C, and D by their respective denominators as shown in the above equation. Thus, the values of R are

$$\frac{18.01}{0.679} = 26.53, \quad \frac{20.21}{0.761} = 26.56, \quad \frac{21.84}{0.825} = 26.48.$$

The same procedure is followed to determine the resistance of $R_s + R_c$. As shown in the data sheet, these values are found to be 4.44, 4.45 and 4.43 ohms. The next step is to average each group of three resistances. The equivalent resistance of the specimen condenser C_x is the difference between these averages, or 26.52 – 4.44 = 22.08 ohms. The next step is to fill in Spaces Nos. 5, 6 and 7 by referring to the calibration charts of the wave meter and the standard condenser. With these values available, the phase difference, or power factor of the specimen, may be computed. As has been previously stated, phase difference expressed in degrees is

$$\psi^\circ = 3.60\ RCf \times 10^{-7}$$

or

$$= 0.1079\ \frac{RC}{\lambda}$$

Assuming the specimen capacity (C) to be 235 micromicrofarads, the wave frequency (f) to be 1000 *kc* per sec. (wave length 300 meters), then the phase difference of the specimen is

$$\psi^\circ = 3.60 \times 22.08 \times 235 \times 1000 \times 10^{-7} = 1.87 \text{ deg.}$$

or

$$= \frac{0.1079 \times 22.08 \times 235}{300} = 1.87 \text{ deg.}$$

This value is inserted in Space No. 8 while the phase difference of the circuit is computed and inserted in Space No. 9. Thus the phase difference of the circuit equals:

$$3.60 \times 4.44 \times 235 \times 1000 \times 10^{-7} = 0.38 \text{ deg.}$$

or

$$\frac{0.1079 \times 4.44 \times 235}{300} = 0.38 \text{ deg.}$$

For the small values of phase difference usually found in the better types of electrical insulating material,

$$\text{power factor in per cent} = 1.75 \times \psi^\circ.$$

This quantity is computed and entered in Space No. 10. The thickness and area of the specimen may now be measured and the values written in Spaces Nos.

11 and 12, respectively. The thickness (T) should be the average of at least six micrometer readings. Having determined the thickness (T) and the area (S), and the capacity (C) (Spaces Nos. 7, 11 and 12), the dielectric constant may be computed from the formula previously given. Assuming T and S to be 0.45 cm. and 284 cm^2. respectively,

$$K = \frac{CT}{0.0885\ S} = \frac{235 \times 0.45}{0.0885 \times 284} = 4.2.$$

The computed value of K is written in Space No. 13. For the better comparison of electrical insulating materials for radio use, both the phase difference and the dielectric constant should be considered. Space No. 14 has been left for the numerical product of phase difference expressed in degrees and the dielectric constant. Thus,

$$\text{Product} = \psi^\circ \times K = 1.87 \times 4.2 = 7.86.$$

TABLE II.—SAMPLE REPORT.

Date of Test, *May 10, 1922.* Specimen Number, *1.*
Specimen submitted by *A B C Co.* Number submitted, 1. Date, *May 1, 1922*
Filler, *Wood flour.* Binder, *X Y Z Resin.* Grade, *No. 2.* Color, *Natural.*
Average thickness, *0.443* cm., ... in. Room temperature, *21*° C., ... °F.
Relative humidity, *54%*.

Wave Frequency, f, kilocycles per sec.	Wave Length, λ, meters.	Computed Values.				Remarks.
		Phase Difference, ψ°, deg.	Power Factor, per cent.	Dielectric Constant, K	Product of $\psi^\circ \times K$	
1071.0	280	2.04	3.57	5.20	10.6	As received.
492.0	610	1.92	3.36	5.28	10.1	
197.4	1520	1.91	3.34	5.34	10.2	
113.6	2640	1.86	3.25	5.37	10.0	
95.0	3160	1.84	3.22	5.40	9.9	
1027.0	292	2.12	3.71	5.40	11.4	After water treatment.
482.5	622	2.02	3.54	5.48	11.1	
195.5	1534	2.01	3.52	5.54	11.1	
112.5	2666	1.96	3.43	5.57	10.9	
93.8	3200	1.94	3.39	5.60	10.9	

Report.—A convenient form for the report is shown in Table II and a summary for 300 and 3000 meters is shown in Table III.

TABLE III.—SAMPLE SUMMARY.

Values of phase difference and dielectric constant, at 300 and 3000 meters wave length as read from curves, Fig. 14.

Wave Frequency.	Phase Difference, ψ°, deg.	Dielectric Constant, *K*	Product of ψ° × *K*
AS RECEIVED, AT 21° C.			
100 *kc* per sec 3000 meters	1.84	5.39	9.92
1000 *kc* per sec. 300 meters	2.02	5.21	10.53
Average	1.93	5.30	10.23
AFTER 48 HOURS IN WATER AT 21° C.			
100 *kc* per sec. 3000 meters	1.94	5.60	10.86
1000 *kc* per sec. 300 meters	2.11	5.40	11.40
Average	2.02	5.50	11.13

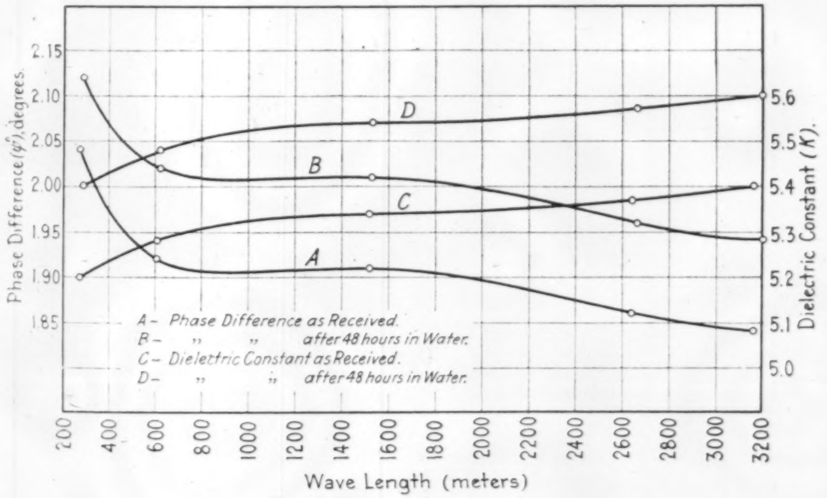

FIG. 14.—Curves for Test Specimen No. 1.

TENTATIVE GENERAL SPECIFICATIONS
FOR
WOODEN BOXES, NAILED AND LOCK-CORNER CONSTRUCTION.[1]

Serial Designation: D 68 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1920; REVISED, 1922.

Types of Boxes Covered. 1. These specifications are intended to apply to wooden boxes of nailed and lock-corner construction, and are directly applicable to the styles of boxes illustrated in Fig. 1.

I. MATERIAL.

Seasoning. 2. The parts shall be made from thoroughly seasoned lumber. Under average conditions, thoroughly seasoned lumber has a moisture content of 12 to 18 per cent of the weight of the wood after oven drying to a constant weight.

Defects. 3. All defects[2] in the lumber that materially lessen the strength of the part, expose the contents to damage, or interfere with the prescribed nailing, shall be eliminated.

Manufacture. 4. Ends, sides, tops, bottoms and other parts of a box shall be well manufactured and cut true to size.

II. GROUPING OF WOODS.

Grouping of Woods. 5. The principal woods used for boxes are classed for the purpose of specifications into four groups, as follows:

GROUP I.

White pine
Norway pine
Aspen (Popple)
Spruce
Western (yellow) pine
Willow
Noble fir
Magnolia
Buckeye
White fir

---

[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. T. R. C. Wilson, Secretary of Committee D-10 on Shipping Containers, Forest Products Laboratory, Madison, Wis.

[2] The committee recognizes that the limitations on defects are not sufficiently definitive. This phase is being made the subject of careful study with the object of recommending more definite requirements.

Cottonwood
Yellow poplar
Balsam fir
Chestnut
Sugar pine
Cypress
Basswood
Cedar
Redwood
Butternut
Cucumber
Alpine fir
Lodgepole pine
Jack pine

GROUP II.

Southern yellow pine
Hemlock
North Carolina pine
Douglas fir
Larch (Tamarack)

GROUP III.

White elm
Red gum
Sycamore
Pumpkin ash
Black ash
Black gum
Tupelo
Maple, soft or silver

GROUP IV.

Hard maple
Beech
Oak
Hackberry
Birch
Rock elm
White ash
Hickory

III. DIMENSIONS OF PARTS.

Thickness of Parts.

6. (*a*) The thicknesses called for in specifications for boxes of any given commodity will, unless otherwise specified, be understood as applying to woods of Groups I and II.

(*b*) When the thicknesses of material in the following table are specified (for Groups I and II woods), woods of Groups III and IV may be used with the following permissible reduction in thickness:

SPECIFIED THICKNESS OF PARTS (GROUPS I AND II).	ALLOWABLE REDUCTION IN THICKNESS FOR GROUPS III AND IV.
¼ to ½ in., incl.	$\frac{1}{16}$ in.
Over ½ to 1 in., incl.	⅛ in.
1 to 2 in., incl.	¼ in.

Occasional Variation in Thickness of Parts.

7. The occasional variation below the thickness of parts specified in Section 6 shall not exceed one-eighth of the thickness of the part.

Number of Pieces.

8. (*a*) The maximum number of pieces allowed in any side, top, bottom or end of a box shall be as follows:

WIDTH OF PART.	MAXIMUM NUMBER OF PIECES.
4 in. and under	1
Over 4 to 7 in., incl.	2
" 7 to 10 in., incl.	3

Over 10 in. shall average not more than one piece for each 3 in. of width and no piece shall be less than 2½ in. in width. Boards matched and fastened as provided in the following section may be not less than 1½ in. in width at either end.

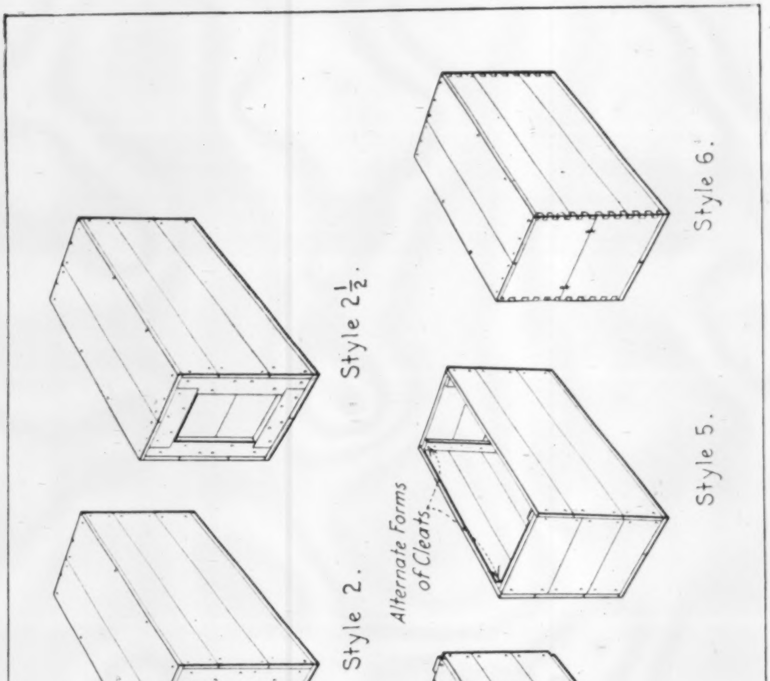
Style 1.
Style 2.
Style 2½.
Style 3.
Style 4.
Style 5.
Style 6.
Alternate Forms of Cleats

FIG. 1.—Styles of Wooden Boxes, Nailed and Lock-Corner Construction.

(*b*) Two or more pieces ½ in. or over in thickness, fastened as follows shall be considered one piece in sides, tops and bottoms: butt-jointed or matched and fastened with two or more corrugated fasteners 1⅛ in. in length and of sufficient width to penetrate approximately three-fourths the thickness of the material.

IV. MANUFACTURE OF BOXES.

Surfacing of Boxes.

9. The outside surface of boxes shall be sufficiently smooth to permit of legible marking. When surfacing of boards two sides is necessary for the protection of the commodities in transportation, the material may be $\frac{1}{32}$ in. thinner than the minimum specified.

Joining.

10. (*a*) Ends ⅞ in. or less in thickness, if made of two or more pieces, shall be: (1) butt-jointed or matched, and fastened with two or more corrugated fasteners; or (2) cleated.

(*b*) The sizes of corrugated fasteners used shall be as follows:

THICKNESS OF END, IN.	SIZE OF FASTENER, IN.
⅜	¼ by 1⅛
$\frac{7}{16}$, ½ and $\frac{9}{16}$	⅜ by 1⅛
⅝, $\frac{11}{16}$ and ¾	½ by 1⅛
$\frac{13}{16}$ and ⅞	⅝ by 1⅛

(*c*) The number of fasteners used shall be as follows:

LENGTH OF END.	NUMBER OF FASTENERS.
16 in. and under	2
Over 16 to 24 in.	3
" 24 " 36 "	4

(*d*) When three or more fasteners are required, they shall be driven alternately from opposite sides of the end.

(*e*) Two or more pieces Linderman jointed shall be considered one piece.

Schedule of Nailing.

Kind of Nails.

11. (*a*) All nails, except as specified in Paragraph (*b*), shall be standard cement-coated box nails of the following length and gage (Washburn and Moen or American Steel and Wire Co. gage):

SIZE OF NAILS, "PENNY."	LENGTH.	GAGE NO.
2	1 in.	16
3	1⅛ "	15½
4	1⅜ "	14
5	1⅝ "	13½
6	1⅞ "	13
7	2⅛ "	12½
8	2⅜ "	11½
9	2⅝ "	11½

(*b*) If other than cement-coated nails are used, 25 per cent more nails shall be driven than specified for cement-coated nails. Plain nails driven through and clinched may be used for cleating.

Size of Nails.

12. The size of nails to be used is determined by the species and thickness of the material in which the points of the nails are held, and shall be in accordance with the following table:

SIZE OF CEMENT-COATED NAILS FOR DIFFERENT SPECIES AND THICKNESS OF MATERIAL.

(The sizes of nails are given in "penny".)

Species of Wood Holding Nails.	Thickness of Ends or Cleats to Which Sides, Tops and Bottoms are Nailed, in.								Thickness of Sides to Which Top and Bottom are Nailed, in.		
	$\frac{3}{8}$ or less	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$ or $\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	Less than $\frac{1}{2}$	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{5}{8}$ to $\frac{7}{8}$
Group I woods	4	5	5	6	7	8	8	9	4	6	7
Group II woods	4	4	5	5	6	7	7	8	4	5	6
Group III woods	3	4	4	5	5	6	7	7	3	4	5
Group IV woods	3	3	4	4	4	5	6	7	3	4	5

NOTE.—If the designated penny of nail is not available, the next lower penny shall be used, and the nails spaced proportionately closer.

Spacing and Number of Nails.

13. (*a*) The spacing of nails holding the side, top or bottom to the ends of a box shall be as follows:

SIZE OF NAILS, "PENNY."	SPACE WHEN DRIVEN INTO SIDE GRAIN OF END.	SPACE WHEN DRIVEN INTO END GRAIN OF END.
6 or less	2 in.	$1\frac{3}{4}$ in.
7	$2\frac{1}{4}$ "	2 "
8	$2\frac{1}{2}$ "	$2\frac{1}{4}$ "
9	$2\frac{3}{4}$ "	$2\frac{1}{2}$ "
10	3 "	$2\frac{3}{4}$ "

(In order to ascertain the number of nails to be used, divide the width of the side, top or bottom (or length of cleat) by the spacing specified for the size of nails to be used. Fractions in the result greater than $\frac{1}{4}$ if the points of nails are to be held in the end grain, and greater than $\frac{1}{2}$ if the points of nails are to be held in the side grain, will be considered as a whole number.)

(*b*) When side nailing is used the spacing of nails holding top and bottom to sides shall be 6 to 8 in. When the material in the sides is less than $\frac{1}{2}$ in. in thickness, side nails shall not be used, unless otherwise specified.

(*c*) No boards shall have less than two nails at each nailing end, except boards less than $2\frac{1}{2}$ in. in width, which are butt-jointed or matched and fastened with corrugated fasteners as specified in Section 8 (*b*) may have only one nail. When cleats of the thickness of the ends are used, the nails shall be driven in the ends and cleats alternately.

(*d*) When box ends are cleated, the spacing of nails holding cleats and ends together shall be the same as the spacing of the nails holding the adjacent side, top, or bottom to the end. Each piece of the end shall be nailed to each cleat with not less than two nails, except that end boards less than $2\frac{1}{2}$ in. in width which are butt-jointed or matched and fastened with corrugated fasteners as provided for in Section 8 (*b*) may have only one nail.

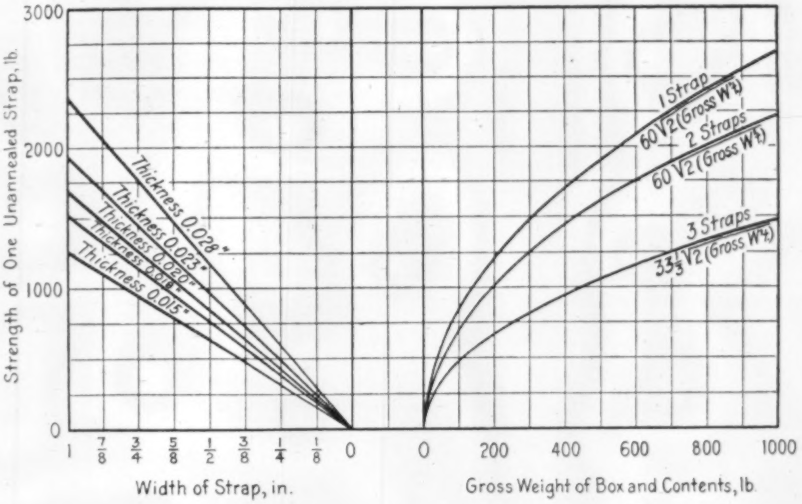

FIG. 2.—Chart for Determining Size of Strap.

(*e*) Nails attaching cleats to ends shall be of sufficient length to penetrate both thicknesses of lumber and allow for clinching. Either cement-coated or plain nails may be used.

(*f*) When cleats are thicker than the ends, nails shall be driven through the end boards into the cleats and clinched.

14. Nails shall be driven flush. **Driving of Nails.**

(Over-driving of nails materially weakens the container.)

V. STRAPPING OF BOXES.

15. When boxes are specified to be strapped with flat metal straps, either (1) unannealed straps without nails or (2) annealed or unannealed straps nailed on, shall be used, subject to the following requirements: **Strapping.**

(*a*) When the straps are nailed on, they shall be placed around the ends of the box and held in position by the same size nails spaced twice the distance specified for holding the box parts together.

(*b*) Metal fasteners used to hold the ends of nailless straps together shall have not less than 75 per cent of the tensile strength of the strap.

(*c*) All straps shall be drawn tight so as to sink into the corners of the box.

(*d*) When two or three nailless straps are used, one shall be placed approximately one-sixth of the length of the box from each end.

(*e*) Fig. 2 gives the size of straps to be used on various gross weights of boxes. Starting with the weight of box and contents, move directly upward to the curve for the number of straps decided upon; then move to the left to an intersection with the line representing the thickness of straps to be used. The first vertical line at or beyond this point of intersection represents the width of strap required; or, move to the left, as above, to the vertical line representing the width of strap decided upon and the first diagonal line above this point of intersection represent the thickness of strap required.

(*f*) Material wider than $\frac{3}{4}$ in. or thicker than 0.023 in. is not ordinarily used for nailless strapping.

Thickness of Parts of Strapped Boxes.

16. The thicknesses specified for sides, tops, and bottoms of unstrapped nailed boxes may be reduced to the thickness indicated below, when metal straps are used:

Specified Thickness of Sides, Tops, and Bottoms of Unstrapped Boxes, in.	Thickness of Sides, Tops, and Bottoms of Strapped Boxes, in.	
	One Strap.	Two or More Straps.
$\frac{7}{8}$	$\frac{5}{8}$	$\frac{1}{2}$
$\frac{13}{16}$	$\frac{5}{8}$	$\frac{1}{2}$
$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{8}$
$\frac{9}{16}$	$\frac{7}{16}$	$\frac{5}{16}$
$\frac{1}{2}$	$\frac{3}{8}$	$\frac{5}{16}$
$\frac{7}{16}$	$\frac{5}{16}$	$\frac{1}{4}$
$\frac{3}{8}$	$\frac{5}{16}$	$\frac{1}{4}$

TENTATIVE SPECIFICATIONS
FOR
COTTON RUBBER-LINED FIRE HOSE FOR PRIVATE FIRE DEPARTMENT USE.[1]

Serial Designation: D 14 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Material Covered. 1. These specifications apply to cotton rubber-lined hose for private use for fire protection purposes. They cover the following sizes: 1½-in. single and double-jacketed; 2-in. single and double jacketed; 2½-in. single, double and triple-jacketed; 3-in. double and triple-jacketed; 3½-in. double and triple-jacketed.

I. MANUFACTURE.

Cotton Fabric. 2. (*a*) The jacket or jackets shall be well, evenly and firmly made from good cotton, as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with good manufacturing practice.

(*b*) The cotton jackets shall be seamless and have the fillers woven around the hose throughout its length and the warps interwoven with and covering the fillers. Where more than one jacket is prescribed, they may be separate or interwoven.

Rubber Lining. 3. (*a*) The lining shall be made of a properly vulcanized rubber compound which will comply with all of the tests specified in Section 8. It shall consist of not less than three calendered sheets in one solid body and shall be lap-jointed with the lap as small and neat as is consistent with good results.

(*b*) The lining shall be smooth and practically free from pitting and other imperfections and from corrugations.

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[1] These Tentative Specifications are in effect a revision of the Standard Specifications for Cotton Rubber-Lined Fire Hose for Private Department Use. The Standard Specifications, which were last published under the Serial Designation: D 14 – 15, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

(*a*) When the straps are nailed on, they shall be placed around the ends of the box and held in position by the same size nails spaced twice the distance specified for holding the box parts together.

(*b*) Metal fasteners used to hold the ends of nailless straps together shall have not less than 75 per cent of the tensile strength of the strap.

(*c*) All straps shall be drawn tight so as to sink into the corners of the box.

(*d*) When two or three nailless straps are used, one shall be placed approximately one-sixth of the length of the box from each end.

(*e*) Fig. 2 gives the size of straps to be used on various gross weights of boxes. Starting with the weight of box and contents, move directly upward to the curve for the number of straps decided upon; then move to the left to an intersection with the line representing the thickness of straps to be used. The first vertical line at or beyond this point of intersection represents the width of strap required; or, move to the left, as above, to the vertical line representing the width of strap decided upon and the first diagonal line above this point of intersection represent the thickness of strap required.

(*f*) Material wider than $\frac{3}{4}$ in. or thicker than 0.023 in. is not ordinarily used for nailless strapping.

Thickness of Parts of Strapped Boxes.

16. The thicknesses specified for sides, tops, and bottoms of unstrapped nailed boxes may be reduced to the thickness indicated below, when metal straps are used:

Specified Thickness of Sides, Tops, and Bottoms of Unstrapped Boxes, in.	Thickness of Sides, Tops, and Bottoms of Strapped Boxes, in.	
	One Strap.	Two or More Straps.
$\frac{7}{8}$	$\frac{5}{8}$	$\frac{1}{2}$
$\frac{13}{16}$	$\frac{5}{8}$	$\frac{1}{2}$
$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{8}$
$\frac{9}{16}$	$\frac{7}{16}$	$\frac{5}{16}$
$\frac{1}{2}$	$\frac{3}{8}$	$\frac{5}{16}$
$\frac{7}{16}$	$\frac{5}{16}$	$\frac{1}{4}$
$\frac{3}{8}$	$\frac{5}{16}$	$\frac{1}{4}$

TENTATIVE SPECIFICATIONS
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I. MANUFACTURE.

Cotton Fabric.

2. (*a*) The jacket or jackets shall be well, evenly and firmly made from good cotton, as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with good manufacturing practice.

(*b*) The cotton jackets shall be seamless and have the fillers woven around the hose throughout its length and the warps interwoven with and covering the fillers. Where more than one jacket is prescribed, they may be separate or interwoven.

Rubber Lining.

3. (*a*) The lining shall be made of a properly vulcanized rubber compound which will comply with all of the tests specified in Section 8. It shall consist of not less than three calendered sheets in one solid body and shall be lap-jointed with the lap as small and neat as is consistent with good results.

(*b*) The lining shall be smooth and practically free from pitting and other imperfections and from corrugations.

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[1] These Tentative Specifications are in effect a revision of the Standard Specifications for Cotton Rubber-Lined Fire Hose for Private Department Use. The Standard Specifications, which were last published under the Serial Designation: D 14 – 15, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

(*c*) The lining shall be of uniform thickness and not less than the lower limit nor more than the upper limit given in item (*b*) of Table I, exclusive of the backing.

(*d*) The backing, if used, shall not exceed 0.028 in. in thickness. It need not be of the same composition as the rubber lining, but the adhesion between the rubber lining and the cotton jacket shall comply with the test specified in Section 9.

Flexibility. 4. The hose shall be flexible and easily coiled.

Workmanship. 5. The character of the workmanship shall be such as is incident to good manufacturing practice.

TABLE I.

Property.	Size and Number of Jackets.										
	1½-in		2-in.		2½-in.			3-in.		3½-in.	
	Single.	Double.	Single.	Double.	Single.	Double.	Triple.	Double.	Triple.	Double.	Triple.
(*a*) Prescribed internal diameter, in.	1½	1½	2	2	2½	2½	2½	3	3	3½	3½
(*b*) Thickness rubber lining, in.	0.049 to 0.065	0.049 to 0.065	0.049 to 0.065	0.049 to 0.065	0.058 to 0.072	0.058 to 0.072	0.058 to 0.072	0.058 to 0.072	0.058 to 0.072	0.072 to 0.095	0.072 to 0.095
(*c*) Test pressure on every length, lb. per sq. in.	300	400	300	400	300	400	400	400	400	400	400
(*d*) Bursting test pressure (3-ft. samples) lb. per sq. in.	500	600	500	600	500	600	600	600	600	600	600
(*e*) Kink test pressure, lb. per sq. in.	250	300	250	300	250	300	300	250	250	250	250
(*f*) Elongation, per cent.	13	9	13	9	13	9	9	9	9	9	9
(*g*) Twist, deg. per ft.	50	29	50	29	25	15	15	15	15	15	15
(*h*) Rise, in.	7	none	7	none	4	none	none	none	none	none	none
(*i*) Weight, min., lb.	21	..	29	..	40	..	..	..	...	...	...
Weight, max., lb.	..	42	..	58	..	70	86	93	113	115	135
(*j*) Test pressure marking, lb. per sq. in.	300	400	300	400	300	400	400	400	400	400	400

II. PHYSICAL PROPERTIES AND TESTS.

Standard Methods. 6. The tests necessary to determine the physical properties which are prescribed in the following sections shall be made in accordance with the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 22 T) of the American Society for Testing Materials.[1]

Sampling. 7. Samples shall be taken both as regards number and location at the discretion of the inspector. All test specimens shall be cut transversely from the sample.

Tests of Rubber Lining. 8. (*a*) The tensile strength shall be not less than 1600 lb. per sq. in. when tested one month or less from date of final vulcanization, and not less than 1200 lb. per sq. in. when tested more than one month but not over one year from date of final vulcanization.

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[1] See p. 947.

(*b*) The tensile strength after subjection to a dry heat of 158° F. (70° C.) for a period of four successive days of 24 hours each shall be not less than 900 lb. per sq. in. This test shall be made within three months from date of final vulcanization.

(*c*) The elongation when rupture occurs in making the tension test (Paragraph (*a*)) shall be such that the original 2-in. gage length shall stretch to not less than 12 in., when tested one month or less from date of final vulcanization, and not less than 10 in. when tested more than one month but not over one year from date of final vulcanization.

(*d*) The permanent elongation or set following a stretch from 2 to 10 in. shall not exceed 25 per cent when tested one month or less from date of vulcanization. When tested more than one month but not over one year from date of final vulcanization, it shall not exceed 25 per cent following a stretch from 2 to 8 in.

9. The adhesion between the lining and the cotton jacket shall be such that the rate of separation of the lining from the jacket of a test piece 1½ in. in width shall be not greater than one inch per minute with the application of a weight of 12 lb. **Friction Test.**

10. (*a*) Each length of hose shall be subjected to the hydrostatic pressure specified in item (*c*) of Table I for five seconds without leaking in the hose or at the couplings or breaking any threads in the jacket. **Hydrostatic Pressure Tests.**

(*b*) A 3-ft. sample in every lot of 3000 ft. of hose or less shall, while lying either straight or curved to a radius of 27 in., withstand without failure the hydrostatic pressure specified in item (*d*) of Table I.

(*c*) One full length in every lot of 500 ft. of hose or less shall, while kinked, withstand without failure the hydrostatic pressure specified in item (*e*) of Table I applied for five seconds.

11. The elongation of the hose when tested as prescribed in Section 10 (*a*) shall not exceed the percentage of the length measured under a pressure of 10 lb. per sq. in. which is specified in item (*f*) of Table I. **Elongation.**

12. When tested as prescribed in Section 10 (*a*), the hose shall not twist more than the amount given in item (*g*) of Table I. The twisting shall be in the direction which will tighten rather than loosen the couplings. **Twisting.**

13. When subjected to the test prescribed in Section 10 (*a*), the hose shall not rise more than the distances specified in item (*h*) of Table I, from the level of the test table or test floor or warp more than 20 in. from a straight line drawn from center to center of the couplings. **Warping.**

III. CHEMICAL PROPERTIES AND TESTS.

Methods.

14. The chemical tests required by the following chemical requirements shall be made in accordance with the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 22 T) of the American Society for Testing Materials.[1]

Sampling.

15. Samples shall be taken both as regards number and location at the discretion of the inspector.

Analysis of Rubber Lining.

16. (*a*) In the analysis of the rubber lining, the acetone extract shall not exceed 4 per cent; the alcoholic potash extract shall not exceed $1\frac{1}{2}$ per cent; the chloroform extract shall not exceed 2 per cent; the ash shall be not less than 50 per cent nor more than 57 per cent; the total sulfur (excluding barytes) shall not exceed 4 per cent; and the free sulfur shall not exceed $1\frac{1}{4}$ per cent. All percentages shall be by weight of the total compound.

(*b*) The sum total of the results of the tests of the rubber lining for acetone extract, alcoholic potash extract, chloroform extract, ash and total sulfur (exclusive of barytes) shall not exceed 67 per cent by weight of the total compound.

IV. DIMENSIONS AND WEIGHTS.

Diameter and Length of Hose.

17. The hose shall have an internal diameter of not less than the diameter ordered and shall be furnished in lengths averaging 50 ft.

Weight of Hose.

18. The weight of each 50-ft. length of hose complete with couplings shall be in accordance with the amount specified in item (*i*) of Table I.

V. COUPLINGS.

Type.

19. Couplings shall be of the type ordered but unless otherwise specified, they shall conform to Sections 20 to 25, inclusive, and Section 28.

Workmanship and Diameter.

20. The couplings shall be made, finished and fitted in a workmanlike manner throughout. The inside diameter throughout the couplings shall be not less than the nominal inside diameter of the hose to which they are connected.

Type and Dimensions.

21. The couplings shall be of the expansion-ring pattern, of ample strength, and of the best form to resist the stress of expanding the binding ring in the coupling, and shall have a tail part sufficiently long to extend $\frac{1}{8}$ in. beyond the end of the expansion ring. The ring shall be at least $1\frac{1}{4}$ in. in length.

Chemical Composition.

22. The couplings shall be made of an alloy of copper, tin and zinc (and lead if desired) of the following proportions:

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[1] See p. 947.

Copper	not under 83 per cent
Tin	" " 5 "
Zinc	" over 7 "
Lead	" " 3 "

Weight. 23. The weight of complete couplings, including male and female ends, swivel, and the expansion rings, shall be not less than the values specified in Table II.

Gasket and Washer. 24. (*a*) The swivels of the couplings shall be provided with rubber gaskets of the same quality as the rubber lining, at least $\frac{3}{16}$ in. thick, and accurately fitted.

TABLE II.—WEIGHT OF COUPLINGS.

Nominal Diameter of Hose, in.	Weight, Complete, lb.		
	Single Jacket.	Double Jacket.	Triple Jacket.
1½	1.5	2.0	....
2	2.5	3.0	....
2½	4.0	5.0	....
3	...	8.0	10.0
3½	...	12.0	14.0

(*b*) The couplings shall have, inside each expansion ring, a rubber washer at least $\frac{3}{16}$ in. in thickness and with inside diameter not less than that of the coupling.

(*c*) The inside diameter of the gasket and the washers when in position in the couplings shall be not less than the inside diameter of the hose to which the coupling is attached.

Thread. 25. Wherever practicable and not otherwise specified, the thread shall be the "National Standard" thread adopted in 1906 by the National Fire Protection Association.

Attachment of Couplings. 26. The couplings shall be attached to the hose in a workmanlike manner without cutting the lining or rupturing the cotton jacket. They shall withstand the hydrostatic pressure tests described in Section 10 (*a*) without the use of tape or rubber tissue as a filler.

VI. MARKING.

Hose. 27. Beginning at a point approximately 4 ft. from the couplings, each 50-ft. length of hose shall be stenciled at two places in black indelible letters 1 in. high with the legend "A.S.T.M. Specifications", the name of the manufacturer, the month and year of manufacture, and the words "Tested at — lb.," the pressure stated to be that given in item (*j*) of Table I.

Couplings 28. Both male and female couplings shall be stamped with the name of the manufacturer and the month and year of manufacture in letters and figures not less than ⅛ in. high.

VII. INSPECTION AND REJECTION.

Inspection. 29. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangement for inspection.

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection. 30. (*a*) Each length of hose that fails in the tests prescribed in Sections 10 (*a*), 11, 12 or 13 shall be rejected.

(*b*) In the case of failure to pass the tests prescribed in Sections 8, 9, 10 (*b*) or 10 (*c*), two additional samples shall be subjected to the test in which failure occurred. If either of these two additional samples fails, the lot of hose from which they were taken shall be rejected.

Rehearing. 31. Samples of rejected hose shall be preserved for two weeks from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

ADHESIVE TAPE FOR GENERAL USE FOR ELECTRICAL PURPOSES.[1]

Serial Designation: D 69 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1920; REVISED, 1921, 1922.

Material Covered. 1. These specifications cover commercial adhesive tape (also called "friction" tape) consisting of strips of cotton sheeting impregnated with an adhesive insulating compound. The tape is for general use for covering electrical insulation applied to wires and cables.

I. MANUFACTURE.

Cotton Sheeting. 2. The cotton sheeting layer shall be made from a sheeting evenly and firmly woven from good cotton and as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice. The threads shall run in as straight lines as possible without waving so as to reduce to a minimum the raveling of the cloth when cut into tape.

Frictioning Compound. 3. The frictioning compound shall be an adhesive and insulating compound practically free from free sulfur or other substances which would have a deteriorating effect on copper or other metals or on the fabric.

Impregnation of Fabric. 4. The fabric shall be thoroughly impregnated and evenly covered on both sides with the frictioning compound.

Adhesiveness of Compound. 5. The compound shall adhere firmly to the fabric and shall not pull away from the fabric so as to leave bare spots when adjacent layers of the tape are separated.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

II. CHEMICAL PROPERTIES.

Discoloration of Copper.

6. When the tape is wrapped on a clean, bright, smooth copper rod and baked at 100° C. for 16 hours, the copper shall not show the blue-black color characteristic of copper sulfide.

III. PHYSICAL PROPERTIES AND TESTS.

Pin Holes.

7. When the tape is held before a strong light, the number of pin holes shall be determined in a length of not less than 3 yd. The number of pin holes shall not exceed the limits given in the following table:

WIDTH, IN.	MAXIMUM NUMBER IN 3 YD.	MAXIMUM NUMBER IN ANY SINGLE YD.
½	6	3
¾	6	3
1	9	4
1½	12	5
2	15	6

Tensile Strength.

8. The tensile strength of the tape shall be not less than 40 lb. per inch of width. The initial distance between the jaws of the testing machine shall be 12 in. and the rate of separation of the jaws shall be 20 in. per minute.

Friction.

9. (*a*) The adhesion between adjacent layers of the tape shall be such that when a strip of tape 2 ft. long is taken from a roll and wound upon a mandrel 1 in. in diameter under a tension of 10 lb. per inch of width at a rate of 30 in. per minute, and allowed to stand for three minutes with the weight attached, a weight of 4 lb. per inch of width shall not cause the plies to separate at a rate greater than 30 in. per minute.

The test shall be made at a room temperature not less than 21.1° C. (70° F.) nor more than 23.9° C. (75° F.), the sample having been kept within these limits for at least 30 minutes immediately preceding the time of testing.

The mandrel shall be so free in its bearings that a weight of 1 oz. will cause it to revolve freely when suspended from a cotton string wound in a single layer on the center of the mandrel.

(*b*) After a strip has been exposed to dry air at a temperature of not less than 99° C. (210.2° F.) nor more than 101° C. (213.8° F.) for 16 hours and then cooled to room temperature, a test specimen shall withstand the test prescribed in Paragraph (*a*) except that the weight applied to unwind the tape shall be 1⅓ lb. per inch of width instead of 4 lb.

Dielectric Strength.

10. The test for dielectric strength shall be made as follows: The tape shall be spirally wound with one-third lap on a smooth

metal rod, 1 in. in diameter, for a distance of 6 in. Two inches in the center shall be covered with metal foil and securely bound with tape. Alternating potential of 1000 volts (r.m.s. value) and having a frequency not exceeding 65 cycles per second shall be applied for five minutes to the metal rod and the metal foil without puncturing the tape.

Test Samples.

11. One roll for each 250 rolls shall be taken at random for test. At least 2 ft. of the outer layers shall be removed and discarded before taking specimens for test.

IV. STANDARD WEIGHT, DIMENSIONS AND VARIATIONS.

Weights, Dimensions and Yardage.

12. The tape shall conform to the following requirements:

WIDTH, IN.	THICKNESS, IN.	NOMINAL WEIGHT PER ROLL, LB.	MINIMUM NET WEIGHT PER 100 ROLLS, LB.[a]	MINIMUM LENGTH PER POUND YD.[a]
$\frac{1}{2}$	0.015	$\frac{1}{4}$	25	82
$\frac{3}{4}$	0.015	$\frac{1}{2}$	50	55
1	0.015	$\frac{1}{2}$	50	41
$1\frac{1}{2}$	0.015	1 or $1\frac{1}{4}$	100 or 125	27
2	0.015	$1\frac{1}{2}$	150	20

[a] Exclusive of core, wrapping and box.

Measurement of Thickness.

13. The thickness shall be measured with a micrometer graduated to 0.001 in., having a circular foot, 0.24 to 0.26 in. in diameter and with a pressure on the specimen of not less than 8 oz. nor more than 10 oz. Five measurements shall be made at random in a length of not less than 3 ft. and no result shall be outside the limits prescribed.

Permissible Variations.

14. The width shall not vary from the specified value by more than $\frac{1}{32}$ in. The thickness shall not vary from the specified value by more than 0.002 in.

V. PACKING AND MARKING

Packing.

15. Each roll shall be wrapped in paraffined paper or metal foil and enclosed in a suitable box. The wrapping shall be secure and shall thoroughly protect the contents.

Marking.

16. Each box shall be marked with the name of the manufacturer or a trade mark together with the nominal width and weight of the tape.

VI. INSPECTION AND REJECTION.

Time of Inspection.

17. The tape shall be inspected and tested within four weeks from the date of delivery.

Retests and Rejections.

18. If the tape fails in any one test of those prescribed in these specifications, two additional specimens will be taken and submitted to that test. If either of these two additional specimens fails, the lot of tape represented by that sample shall be rejected.

TENTATIVE SPECIFICATIONS
FOR
RUBBER INSULATING TAPE.[1]

Serial Designation: D 119 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

Material Covered. 1. These specifications cover rubber insulating tape to be used for insulating joints in electric wires and cables.

I. MANUFACTURE.

Compound 2. The tape shall be a rubber compound which shall be well, evenly and smoothly calendered, cut to uniform width and tightly wound in rolls with a glazed cloth, parchment paper or a linen separator interposed between adjacent layers.

Separator. 3. The separator shall be attached to and cover the outer side of the tape. When unwound from the original roll, it shall show no undue tendency to stick to the rubber.

II. CHEMICAL PROPERTIES AND TESTS.

Composition. 4. The tape shall be a rubber compound containing not less than 30 per cent of the best quality Hevea rubber, not more than one per cent of free sulfur and not more than 4 per cent of waxy hydrocarbons.

The remainder shall consist only of suitable dry inorganic mineral fillers. The compound shall contain no reclaimed rubber, substitutes or organic matter other than herein above specified. All percentages shall be based on the weight of the original compound.

Chemical Analysis. 5. If an analysis of the compound is made, it shall be carried out in accordance with Sections 15 to 47, inclusive (Joint Rubber Insulation

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

Committee's Procedure), of the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 - 22 T) of the American Society for Testing Materials, with the following exceptions:

(*a*) Omit "chloroform extract" from the diagram in Fig. 1 and from the tabulation in Section 45.

(*b*) In place of Section 20 substitute the following: "Remove the rubber compound from the separator and cut into as thin strips as possible."

(*c*) Omit Sections 25 and 33.

(*d*) In Section 34, substitute "acetone" for "chloroform" in the first and second lines.

(*e*) In Section 38, omit "from the conductor" in the third and fourth lines.

(*f*) In Section 46, omit "and chloroform" and substitute "extract" for "extracts" in the first sentence. Omit the second sentence.

(*g*) In Section 47, omit "chloroform extract."

III. PHYSICAL PROPERTIES AND TESTS.

Tensile Strength.

6. (*a*) The tensile strength of the tape shall be not less than 300 lb. per sq. in.

(*b*) The tests shall be made with a power driven, pendulum-type tension testing machine; the initial distance between the jaws shall be 3 in. and the rate of separation of the jaws shall be 20 in. per minute. The width of the test specimen shall be 0.5 in.

(*c*) Three specimens of each sample free from visible flaws shall be tested. The average result shall be taken as the tensile strength.

(*d*) The temperature of the room shall be not lower than 65° F. (18° C.) nor higher than 90° F. (32° C.) and the samples shall have been kept within these temperature limits for at least 30 minutes previous to the time of testing.

Dielectric Strength.

7. Two brass-ball sphere electrodes 2 cm. in diameter shall be brought so close together that the sample of tape can be just moved between them. The tape shall withstand without puncturing the application of a potential of 10,000 volts (r.m.s. value) for a period of five minutes applied to the sphere electrodes at a frequency not exceeding 65 cycles per second.

Fusion.

8. The tape when wrapped to a thickness of $\frac{1}{4}$ in. and heated to a temperature of 150° F. (65.5° C.) for 20 minutes shall fuse into a homogeneous mass.

Test Samples.

9. One roll for each 250 rolls shall be taken at random for test. At least 2 ft. of the outer layers shall be removed and discarded before taking specimens for test.

IV. STANDARD WEIGHTS, DIMENSIONS AND VARIATIONS.

Thickness, Weight and Yardage.

10. The tape shall conform to the following requirements:

WIDTH, IN.	THICKNESS, IN.	NOMINAL WEIGHT PER ROLL, LB.	MINIMUM NET WEIGHT PER 100 ROLLS, LB.[a]	MINIMUM LENGTH PER POUND, YD.[b]
½	0.030	½	50	26¼
¾	0.030	½	50	17½
1	0.030	1	100	13

[a] Exclusive of core, wrapping and box.

[b] Exclusive of core, wrapping, box and separator.

Permissible Variations.

11. The width shall not vary from the specified value by more than $\frac{1}{32}$ in. The thickness shall not vary from the specified value by more than 0.003 in.

Measurement of Thickness.

12. The thickness shall be measured with a micrometer graduated to 0.001 in. having a circular foot, 0.24 to 0.26 in. in diameter, and with a pressure on the specimen of not less than 8 oz. or more than 10 oz. Four measurements shall be made at random in a length of not less than 3 ft. and no measurement shall be outside the limits prescribed in Sections 10 and 11.

V. PACKING AND MARKING.

Packing.

13. Each roll shall be wrapped in paraffined paper or metal foil and enclosed in a suitable box. The wrapping shall be secure and shall thoroughly protect the contents.

Marking.

14. Each box shall be marked with the name of the manufacturer or trade mark and the nominal width and weight of the tape.

VI. INSPECTION AND REJECTION.

Time of Inspection.

15. The tape shall be tested and inspected within four weeks of the date of delivery.

Retest and Rejection.

16. If the tape fails in any one test of those prescribed in these specifications, two additional specimens shall be taken and submitted to that test. If either of these two additional specimens fails, the lot of tape represented by that sample roll shall be rejected.

TENTATIVE SPECIFICATIONS
FOR
RUBBER GLOVES FOR ELECTRICAL WORKERS ON APPARATUS OR CIRCUITS NOT EXCEEDING 3000 VOLTS TO GROUND.[1]

Serial Designation: D 120 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

SPECIFICATIONS.

Material Covered.

1. These specifications cover electrical workers' rubber gloves of two classes:

Class A.—Gloves intended for use without external protection.

Class B.—Gloves intended for use with external protection of leather or other material.

I. MANUFACTURE.

Process.

2. The gloves shall be made by the "dipping" process, of high-grade rubber or rubber compound properly vulcanized, and shall be reversible. Unless otherwise specified cuff edges shall be finished with a roll.

II. PHYSICAL PROPERTIES AND TESTS.

Methods.

3. All tests shall be made in accordance with the methods described in Sections 15–26 inclusive.

(*A*) *Electrical.*

Voltage and Leakage Tests.

4. (*a*) Each glove shall withstand an alternating potential of 10,000 volts (r.m.s. value) for three minutes without showing a leakage current of more than 10 milliamperes at any time during the test.

(*b*) Each glove shall be capable of withstanding the application of the following voltage (r.m.s. value) for one minute without showing a leakage current in excess of that given below:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

	VOLTS.	MILLIAMPERES.
Class A	16 000	18
Class B	14 000	14

(*B*) *Mechanical.*

Tensile Strength, Elongation and Set.

5. A standard test specimen cut from any glove shall have the following physical properties:

(*a*) The tensile strength shall be not less than 1200 lb. per sq. in.

(*b*) The total elongation at rupture shall be not less than 500 per cent in 2 in. (2 in. stretched to 12 in.).

(*c*) The set following a stretch from 2 to 12 in., shall not exceed 0.7 in.

III. STANDARD SIZES AND DIMENSIONS.

Size and Length.

6. (*a*) The size of each glove shall be as specified subject to a permissible variation of $\pm\frac{1}{4}$ in. and shall be expressed in inches as measured around the palm at the base of knuckles.

(*b*) Unless otherwise specified the length of each glove from the tip of the second finger to the edge of cuff, shall be 14 in. subject to a permissible variation of $\pm\frac{1}{2}$ in.

Thickness.

7. The respective thicknesses of the two classes of gloves in inches shall be within the following limits:

	PART OF GLOVE OTHER THAN CROTCH.		CROTCH.	
	MAXIMUM.	MINIMUM.	MAXIMUM.	MINIMUM.
Class A	0.065	0.050	0.065	0.038
Class B	0.050	0.030	0.050	0.022

IV. WORKMANSHIP AND FINISH.

Surface Defects.

8. Gloves shall be free from patches, blisters, pinholes, cracks, protuberances, embedded foreign matter or other physical defects which can be detected by thorough surface inspection.

V. MARKING AND PACKING.

Marking.

9. Unless otherwise specified each glove shall be marked with the manufacturer's name and the size of glove. Such marking shall be confined to the back of the glove and shall be so done as not to injure the glove. Indelible and non-conducting ink shall be used.

Packing.

10. Each pair of gloves shall be packed in an individual stiff paper box of sufficient strength to properly protect the gloves. The end of the box shall be marked with the glove size and in the case of Class B gloves with the words "For use with Protectors."

VI. GUARANTEE.

Guarantee.

11. The manufacturer shall replace, without cost to the purchaser, gloves which at any time within a period of eight months from the date

of initial test, fail to pass the tests herein prescribed; provided the gloves have been properly stored in their original boxes.

NOTE.—"Proper storage" is to be interpreted to mean that gloves are not to be stored directly above or in proximity to steam radiators or other sources of artificial heat. It is desirable that the ambient temperature be not in excess of 90° F. (32.2° C.).

VII. INSPECTION AND REJECTION.

Place and Time of Tests.

12. Inspection and test unless otherwise specified shall be made within two weeks of receipt by the purchaser at his own expense at such place as he may designate.

Rejections.

13. (*a*) Each glove that fails to meet the requirements of Sections 4 (*a*) or 8 shall be rejected. In the case of gloves failing to meet the requirements of Sections 6, 9 and 10 rejection is optional with the purchaser.

(*b*) If any of the measurements of thickness made as prescribed in Section 16 or any additional measurements which the purchaser may elect to make fall below the minimum thickness specified in Section 7, the glove shall be rejected. If any of the measurements exceed the maximum thickness specified, rejection is optional with the purchaser.

(*c*) If rejections under Paragraphs (*a*) and (*b*) exceed 25 per cent of the shipment the whole shipment may be rejected without further tests.

(*d*) If 50 per cent or more of the gloves subjected to the test prescribed in Section 4 (*b*) fail to pass the test, the entire shipment shall be rejected.

(*e*) If the average of the results for either the tensile strength, elongation or set tests made as prescribed in Section 26 fail to meet the requirements of Section 5, the entire shipment shall be rejected.

Marking Rejected Gloves.

14. All rejected material shall be returned to the manufacturer without being defaced by rubber stamp or other permanent marking, excepting gloves which have been punctured on electrical tests. These shall be stamped, punched or cut to indicate that they are unfit for electrical use.

METHODS OF TEST.

Order of Procedure.

15. The order of procedure in testing rubber gloves shall preferably be as follows:[1]

(*a*) Inspection of inside and outside surfaces (see Section 8).

(*b*) Measurement of length (see Section 6 (*b*)).

(*c*) Measurement of size (see Section 6 (*a*)).

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[1] This procedure has been found by experience to minimize the expense of the inspection and testing, particularly where an appreciable number of gloves fail to meet the requirements as to workmanship or dimensions.

(*d*) Measurement of thickness (see Section 7).
(*e*) Electrical test (see Section 4 (*a*)).
(*f*) Dielectric strength (see Section 4 (*b*)).
(*g*) Mechanical test (see Section 5).

VIII. DIMENSIONS.

Thickness. 16. (*a*) The thickness of each glove shall be measured at not less than four points on the face and four points on the back.

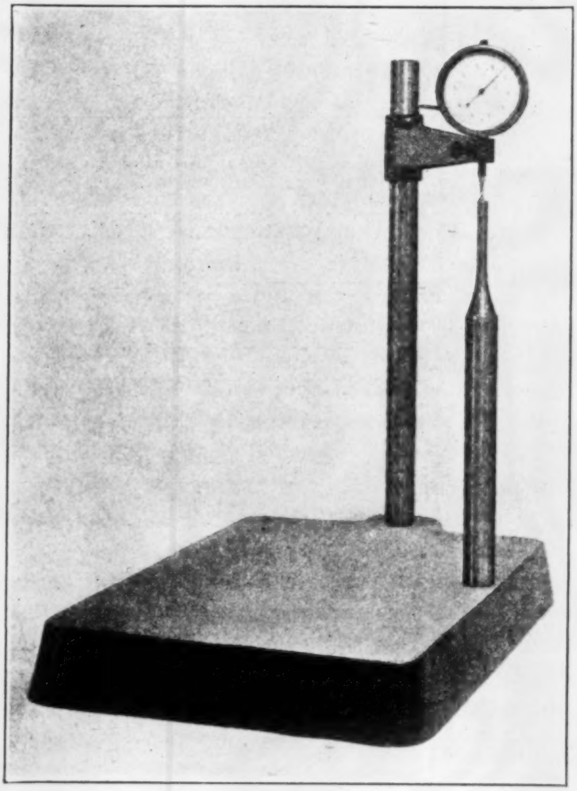

FIG. 1.—Dial Micrometer.

(*b*) Measurements shall be made at one or more points in the crotch of thumb and index finger and in the crotches between the fingers.

(*c*) These measurements shall be made with any micrometer graduated to mils or tenths of mils having a ratchet friction or spring attachment. The tension on the friction attachment should be so adjusted that when the spindle has come to a stop, the specimen can be moved between the spindle and anvil without causing any appreciable stretching of the rubber.

A dial-type micrometer graduated to mils and mounted in a manner similar to that shown in Fig. 1 is particularly convenient for making all of these measurements, especially the crotches. The anvil is about $\frac{1}{4}$ in. (6.4 mm.) in diameter and the foot of the spindle about $\frac{1}{8}$ in. (3.2 mm.) in diameter.

IX. ELECTRICAL TESTS.

Leakage. 17. Each glove shall be tested for leakage in fresh water at normal room temperature (60 to 90° F.) by immersing in the water to within about $1\frac{1}{2}$ to 2 in. of the edge of the cuff and filling with water up to the same point. The water inside the glove and that outside the glove form the test electrodes. These are conveniently connected to the testing transformer by means of a chain suspended in the glove and by direct connection to the containing vessel.

Source of Test Voltage. 18. The testing voltage shall be obtained from a testing equipment, no part of which has a testing capacity of less than $\frac{1}{2}$ kva. per glove being tested. In no case shall the rating of any part of the testing apparatus be less than 2 kva. The frequency of the testing voltage shall be not more than 65 cycles.

Application of Test Voltage. 19. The potential shall be applied at a low value and gradually and steadily raised at a rate of approximately 800 to 1000 volts per second until the prescribed testing voltage is reached.

Test Period. 20. The test period shall be counted from the instant when the prescribed testing voltage is reached.

Voltage Regulation. 21. The method of regulating the testing voltage shall be one which does not distort the wave form of the testing voltage from a sine wave. Acceptable methods include:

(*a*) Field regulation of the alternator supplying the transformer;

(*b*) Induction-type regulator;

(*c*) Variable-ratio-transformer type of regulator;

(*d*) Potentiometer type of rheostatic control where the current in the portion of the potentiometer resistance in parallel with the primary of the transformer is at least five times the exciting current of the transformer.

Voltage Measurement. 22. The testing voltage shall be measured by one of the following methods:

(*a*) A properly calibrated electrostatic voltmeter connected directly across the gloves under test.

(*b*) Any properly calibrated commercial type of alternating voltmeter connected to the low tension side of the transformer in conjunction with the ratio of transformation of the transformer provided that the ratio is definitely known for all test conditions.

(*c*) A calibrated potential transformer with a voltmeter.

Leakage Current Measurement.

23. The leakage current shall be measured by one of the following methods:

(*a*) Directly, by inserting a milliammeter in series with each individual glove in turn.

NOTE.—It is customary to make high voltage tests of this character with one end of the circuit grounded, the containing vessel usually being the grounded end of the circuit. The milliammeter should therefore be connected in at the grounded end of the circuit and shunted by a short circuiting automatic self-closing switch which will therefore always keep the circuit closed except at the instant of reading and thus maintaining an uninterrupted ground.

(*b*) By an ammeter in the low tension circuit of the testing transformer. In this case the leakage current shall be determined by noting the decrease in the low tension current when *one glove at a time* is disconnected from the high tension testing circuit, the voltage being left on the test circuit and the remaining gloves in the meantime. The difference in the two currents divided by the ratio will give the leakage current for the glove disconnected from the circuit.

NOTE.—This method is inaccurate where only one or two gloves are being tested at a time because of the neutralizing effect of the leading current taken by the gloves on the magnetizing current, which is a lagging one. This effect is usually negligible with three or more gloves. The minimum number of gloves which may be safely measured in this manner is easily determined by noting the leakage current of a particular glove when tested with 1, 2, 3, etc., additional gloves, respectively.

Dielectric Strength Test.

24. (*a*) One per cent of the gloves (in no case less than two gloves) which have passed all the tests previously prescribed herein shall be selected at random and tested for compliance with Section 4 (*b*) and also for ultimate dielectric strength. The tests shall be made in accordance with the general method described in Sections 17 to 23 inclusive. If the glove passes the test prescribed in 4 (*b*), the potential shall be raised steadily and gradually at a rate of approximately 1000 volts per second until failure occurs, the voltage at failure being recorded.

(*b*) If any glove fails to meet the requirements of Section 4 (*b*), an additional glove shall be selected at random and tested.

X. MECHANICAL TESTS.

Test Specimens.

25. Four or more standard test specimens shall be cut from each glove tested under Section 24. The shape of these specimens shall be in substantial accordance with that prescribed in the Tentative

Methods of Testing Rubber Products (Serial Designation: D 15 - 22 T) of the American Society for Testing Materials.[1] The essential dimensions of this sample are:

Total length: 6 in.

Width: 1 or $1\frac{1}{4}$ in. with a reduced section at the center, $\frac{1}{2}$ in. wide and about 2 in. long with radii of curvature between the ends and reduced section of $\frac{7}{8}$ in.

Tensile Strength, Elongation and Set.

26. The tests for tensile strength, elongation and set shall be made in accordance with the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 - 22 T) of the American Society for Testing Materials.[1] The essential features of these methods are:

(*a*) Temperature of testing room and of specimens, between 65 and 90° F.

(*b*) Rate of separation of jaws of testing machine, 20 in. per minute.

(*c*) Tensile strength and elongation shall be made on one sample and set test on a separate sample.

(*d*) Set test shall be made by stretching the 2-in. gage length to 12 in., holding for ten minutes and measuring the distance between the bench marks 10 minutes after release.

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[1] See p. 947.

TENTATIVE SPECIFICATIONS
FOR
RUBBER PUMP VALVES.[1]

Serial Designation: D 151 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922

Material Covered.

1. These specifications cover rubber valves for pumps equipped with grid-type seats and which are used for pumping fluids having very slight, if any, effect on rubber.

Classes.

2. Rubber pump valves shall be classified according to the service for which they are intended as follows:

(*a*) *Class 100.*—Vulcanized hard for hot water at a temperature of 150 to 220° F. and a pressure less than 300 lb. per sq. in.

(*b*) *Class 200.*—Vulcanized medium hard for water at a temperature of less than 170° F. and a pressure less than 350 lb. per sq. in.

(*c*) *Class 300.*—Vulcanized medium soft for water at a temperature less than 170° F. and a pressure less than 200 lb. per sq. in.

(*d*) *Class 400.*—Vulcanized soft for water at a temperature less than 170° F. and a pressure less than 50 lb. per sq. in.

(*e*) *Class 500.*—Vulcanized extra soft for water at a temperature less than 170° F. and a pressure less than 20 lb. per sq. in.

I. MANUFACTURE.

Manufacture.

3. The valves shall consist of properly vulcanized rubber compound and all surfaces shall be smooth and free from pitting, blisters, air checks and other imperfections. The thickness shall be uniform throughout and the circumference shall be concentric with the hole at the center.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Requirements.

4. (*a*) The compound shall conform to the requirements specified in Table I expressed as percentages, by weight, of the total.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1923, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

TABLE I.

CLASS.	RUBBER, MINIMUM, PER CENT.	SULFUR, MAXIMUM, PER CENT.[a] TOTAL.	SULFUR, MAXIMUM, PER CENT.[a] FREE.	ORGANIC ACETONE EXTRACT, MAXIMUM, PER CENT.
100	30	7.5	1.0	2.0
200	32	5.0	1.0	2.0
300	35	4.0	1.0	2.0
400	38	3.0	0.75	2.5
500	40	3.0	0.75	2.5

[a] Exclusive of sulfur in barytes.

(*b*) The remainder of the compound shall consist of suitably pulverized inorganic mineral fillers, which may contain barytes, but which shall be practically free from any substance likely to have a deleterious effect on the compound.

(*c*) The compound shall contain no rubber substitute of any kind, rubber which has been previously used or reclaimed rubber.

Chemical Analysis.

5. Chemical analyses of the compound shall be made in accordance with the appropriate section of those numbered from 1 to 14, inclusive, of the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 22 T) of the American Society for Testing Materials.[1]

III. PHYSICAL PROPERTIES AND TESTS.

Specific Gravity.

6. The specific gravity of the valves shall not exceed the values given in Section 7 (*b*).

Plastometer Readings.

7. (*a*) Plastometer readings shall be taken by noting the depth of indentation in millimeters produced by a spherical surface 3.2 mm. (0.125 in.) in diameter under a dead weight pressure of 1 kg. (2.2 lb.) applied for one minute. The test shall be made at a temperature not less than 60° F. nor more than 80° F.

(*b*) The readings obtained on any valve shall not be outside the limits specified in Table II:

TABLE II.

CLASS.	PLASTOMETER READING, LIMITS.	SPECIFIC GRAVITY MAXIMUM.
100	0.03 – 0.10	1.75
200	0.25 – 0.40	1.70
300	0.55 – 0.70	1.65
400	0.85 – 1.00	1.60
500	1.40 – 1.55	1.60

Heat Tests.

8. No valve, when cut in half and subjected to the following dry heat and steam tests, shall show any disintegration, blistering or other defects either on the surface or in the interior when cut open with a knife:

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[1] See p. 947.

(*a*) *Dry heat test.*—One-half of valve at 270° F. (±5° F.) dry heat for one hour.

(*b*) *Steam test.*—One-half of valve in steam at 400° F. (±5° F.) for three hours, the steam pressure to be gradually reduced to atmospheric pressure at the end of the test.

IV. STANDARD SIZES.

Dimensions.

9. The dimensions of the valves shall be as specified by the purchaser.

Permissible Variations.

10. The dimensions (diameter and thickness) shall not vary more than $\frac{1}{32}$ in. from those specified.

V. MARKING.

Marking.

11. Each valve shall be branded on the edge with the letters "A.S.T.M.", the class number, the name of the manufacturer, and the month and year of manufacture.

VI. INSPECTION.

Number of Samples.

12. The number of valves selected for inspection and for chemical and physical tests shall be determined by the purchaser.

Inspection and Tests.

13. (*a*) The purchaser may make the inspections and tests to govern the acceptance or rejection of the valves in his own laboratory or elsewhere, but such inspections and tests shall be made at the expense of the purchaser.

(*b*) If the inspections and tests are made at the place of manufacture, the manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the valves are being furnished in accordance with these specifications. Such inspections and tests shall be so conducted as not to interfere unnecessarily with the operation of the works.

TENTATIVE METHODS OF TESTING RUBBER PRODUCTS.[1]

Serial Designation: D 15 - 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

I. CHEMICAL TESTS

(*A*) *Short Procedure.*

I. GENERAL INSTRUCTIONS.

Blanks.

1. Blank tests shall be run on all determinations and deductions made accordingly.

Checks.

2. In the event of any determination not falling within the limits given in these methods of test, a duplicate determination which shall agree within the limits specified shall be made and the average value taken as the true value.

Preparation of Specimen.

3. (*a*) A specimen weighing not less than 15 g. shall be prepared, taking pieces from various parts of the sample.

(*b*) The specimen shall be cut into small pieces and run through a grinder until all of it will pass through a 20-mesh sieve. Care must be taken that the grinder does not become appreciably warm. The backing shall be buffed off before grinding.

Removal of Iron and Care of Specimen.

4. A strong magnet shall be passed through the specimen to remove any metal from the grinder, and the specimen shall be mixed thoroughly and put in tightly stoppered bottles. It shall not be exposed to sunlight or heat.

II. REAGENTS.

Acetone.

5. Acetone shall be distilled not more than 10 days before use over anhydrous potassium carbonate, using the fraction which distills at 56 to 57° C.

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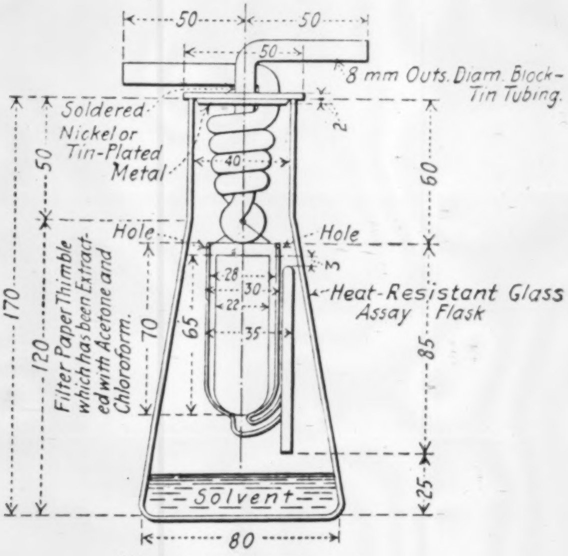
[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1923, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

These tentative methods, when adopted as standard, will supersede the present Standard Methods of Testing Cotton Rubber-Lined Hose (Serial Designation: D 15 – 15), 1921 Book of A.S.T.M. Standards.

Alcoholic Potash. 6. Alcoholic potash shall be of normal strength, made by dissolving the required amount of KOH in absolute alcohol the day before use, and allowing to settle. Only the clear solution shall be used.

Barium-Chloride Solution. 7. Barium-chloride solution shall be made by dissolving 100 g. of crystallized barium chloride in one liter of distilled water and adding two or three drops of concentrated hydrochloric acid. If there is any insoluble matter or cloudiness, the solution shall be heated on the steam bath over night and filtered.

All reagents shall be of a purity equal to that called for in Krauch's "Standard Chemical Reagents; their Purity and Test."


50
50
50
8 mm Outs. Diam. Block-Tin Tubing.
2
Soldered Nickel or Tin-Plated Metal
40
50
60
170
120
Filter Paper Thimble which has been Extracted with Acetone and Chloroform.
Hole
Hole
3
70
65
28
30
22
35
Heat-Resistant Glass Assay Flask
85
25
Solvent
80

(All dimensions in millimeters.)

FIG. 1.—Extraction Apparatus.

III. ANALYSES.

Acetone Extract. 8. The extraction apparatus shall conform to that shown in Fig. 1. It shall be heated so that the period of filling an empty siphon cup with acetone and completely emptying it will be between $2\frac{1}{2}$ and $3\frac{1}{2}$ minutes.

Two grams of the rubber shall be extracted continuously with acetone for 8 hours, using a sample that has been prepared within 24 hours. Distill off the acetone and dry the flask and contents for 4 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down from the side of the flask.

Free Sulfur. 9. Add to the flask containing the acetone extract 50 to 60 cc. of distilled water and 2 or 3 cc. of bromine (if the acetone extract indicates a large amount of free sulfur, the amount of bromine should be increased). Heat gently on the steam bath until the solution is practically colorless and filter into a 400-cc. beaker. Dilute with distilled water until the volume is about 400 cc. Cover the beaker with a watch glass, heat to boiling on the steam bath, add 10 cc. of 10-per-cent barium-chloride solution and allow the precipitate to stand over night. The next day filter off the precipitate, ignite the filter paper and weigh.

Alcoholic-Potash Extract. 10. Dry the residue from the acetone extraction at 50 to 60° C., put into a 200-cc. Erlenmeyer flask with 50 cc. of the alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution into a beaker and wash twice, using each time 25 cc. of hot absolute alcohol and then wash thoroughly with hot water. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. 5 *N* HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool, add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portion of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Total Sulfur 11. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion. Then bring to quiet fusion for 15 to 20 minutes, applying heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate if silica is present; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 400 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent barium-chloride solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

Ash. 12. Weigh out a 1-g. sample in a porcelain crucible, heat in a muffle furnace, the temperature of which is carefully regulated so that no material amount of visible products are given off. After the mass is charred, the temperature shall be raised sufficiently to burn the carbon. The whole process shall be conducted at as low a temperature as possible. At the end of this operation the crucible shall be removed from the furnace, cooled in a desiccator and weighed; the ash broken up and inspected for carbon. If any visible carbon is present, a new determination shall be conducted.

IV. CALCULATIONS.

Calculations. 13. The percentage of rubber shall be considered to be the difference between 100 and the sum of the total sulfur and ash expressed as percentages and figured on the total compound. If the alcoholic-potash extract is over 2 per cent of the rubber as first calculated, subtract this excess also from the rubber. The organic-acetone extract shall be obtained by taking the difference between the total acetone extract and the free sulfur. The organic-acetone extract, free sulfur, total sulfur and alcoholic-potash extract shall be figured on the amount of gum as found by the above procedure.

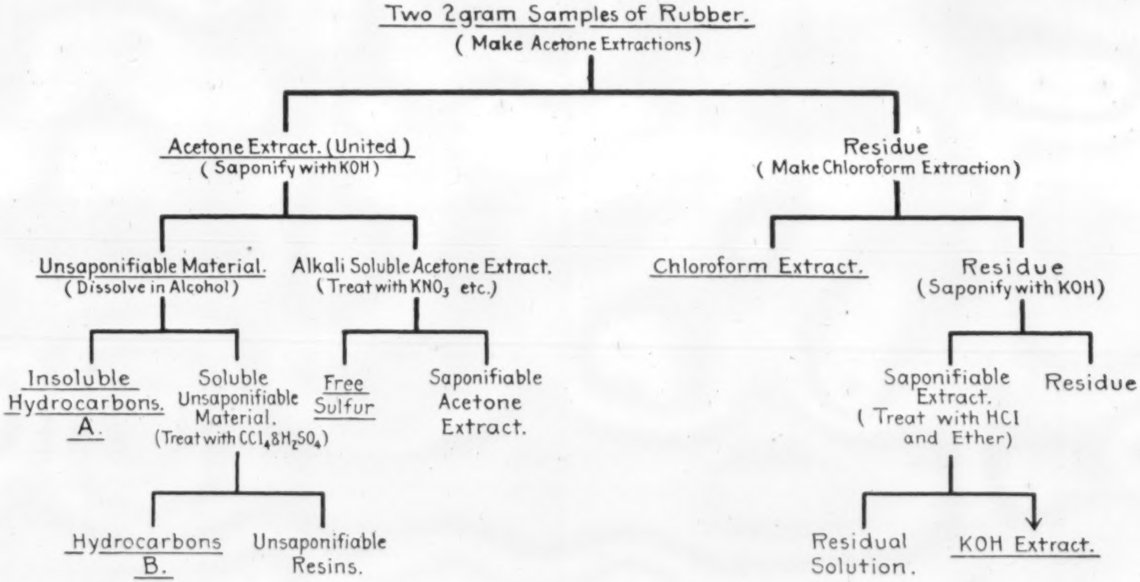
V. CHECK ANALYSES.

Check Analysis. 14. Duplicate determinations when required shall check within the following limits, expressed as percentages of the gum present, as found by analysis, except as stated.

	Check Within, per cent.
Organic-acetone extract	0.10
Free sulfur	0.10
Total sulfur	0.10
Alcoholic-potash extract	0.10
Ash calculated on total compound	0.25

(*B*) *Complete Procedure.*

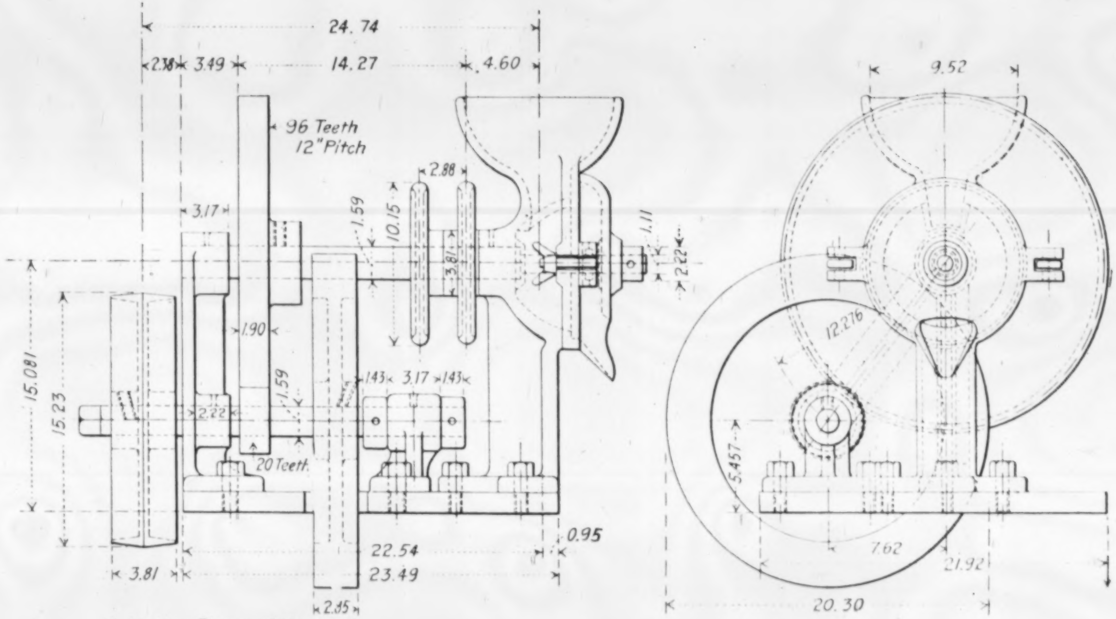
NOTE.—The following is the procedure of the Joint Rubber Insulation Committee and was originally prepared for 30-per-cent Hevea rubber insulation for wires and cables. It is applicable to similar rubber compounds used for other


Two 2gram Samples of Rubber.
(Make Acetone Extractions)
Acetone Extract. (United)
(Saponify with KOH)
Residue
(Make Chloroform Extraction)
Unsaponifiable Material.
(Dissolve in Alcohol)
Alkali Soluble Acetone Extract.
(Treat with KNO₃ etc.)
Chloroform Extract.
Residue
(Saponify with KOH)
Insoluble Hydrocarbons. A.
Soluble Unsaponifiable Material.
(Treat with CCl₄ & H₂SO₄)
Free Sulfur
Saponifiable Acetone Extract.
Saponifiable Extract.
(Treat with HCl and Ether)
Residue
Hydrocarbons B.
Unsaponifiable Resins.
Residual Solution.
KOH Extract.

Total Waxy Hydrocarbons = A + B.

Weigh Substances with Names Underlined; Other Substances by Difference.

FIG. 2.—Outline of Method For Rubber Analysis.
(Exclusive of Fillers and Total Sulfur Determinations.)


24.74
2.38
3.49
14.27
4.60
96 Teeth
12" Pitch
3.17
2.88
1.59
10.15
3.81
1.11
2.22
15.081
15.23
1.90
1.59
1.43
3.17
1.43
2.22
20 Teeth
0.95
22.54
23.49
3.81
2.85
9.52
12.276
5.457
7.62
21.92
20.30

Grinding Plates of the No. 0 Enterprise Coffee Mill to be Used.

(All Dimensions in Centimeters)

FIG. 3.—Diagram for Rubber Grinder.

purposes, but obviously in such cases the references in this procedure to insulation for wires and cables should be disregarded.

Object of Analysis. 15. The object of this procedure of analysis is to determine whether rubber compounds comply chemically with specifications which are intended to secure compounds containing 30 per cent of the best Hevea rubber, and mineral fillers.

Outline. 16. The general procedure is shown in Fig. 2.

VI. GENERAL INSTRUCTIONS.

Samples. 17. (*a*) The analysis shall be made upon the compound after vulcanization.

(*b*) In the case of insulation from wires and cables, samples for analysis shall be taken before the saturation of the braid whenever possible. The insulation shall be thoroughly wiped with a damp cloth to remove any adhering material but without removing waxy hydrocarbons from the surface.

(*c*) If a sample of insulation from wires and cables has to be taken after the braid has been saturated, the braid shall be removed and the insulation sand-papered to a depth of 0.005 in. and then wiped with a damp cloth. The condition of the sample shall be reported.

Duplicate Analyses. 18. All determinations shall be performed in duplicate and the average value taken arbitrarily as the true value. Duplicate determinations shall check within the limits specified.

Blanks. 19. Blanks shall be made on all determinations and the results deducted accordingly.

Preparation of Sample of Insulation. 20. The insulation shall be removed entirely from sufficient wire to give a sample weighing about 25 g. This shall be cut into small strips and ground slowly, so as not to heat the rubber, in either a No. 0 Enterprise coffee mill, a Russwinn grinder or a mill such as shown in Fig. 3. The grinder shall be adjusted so that not more than 20 per cent will pass through a 40-mesh sieve. All of the material shall be sifted through a 20-mesh sieve, what is retained on the sieve being reground until the entire sample has passed through. The wires of the sieves shall be evenly spaced in both directions and shall be of 0.016 and 0.010 in. in diameter in the 20 and 40-mesh sieves, respectively. Any metal that may have come from the grinder shall be removed with a strong magnet and the sample thoroughly mixed.

Extraction Apparatus. 21. The extraction apparatus shall conform to Fig. 1. It shall be heated so that the period of filling an empty siphon cup with acetone and completely emptying it will be between $2\frac{1}{2}$ and $3\frac{1}{2}$ minutes.

VII. REAGENTS.

Acetone. 22. Acetone shall be freshly distilled over anhydrous K_2CO_3, using the fraction 56–57° C.

KOH. 23. Alcoholic KOH solution shall be of normal strength and shall be made freshly by dissolving the proper amount of KOH (purified by alcohol) in 95-per-cent alcohol which has previously been distilled over KOH. The solution shall be allowed to stand for 24 hours and only the clear liquid used.

Ether. 24. Ether shall be washed with three successive portions of distilled water and distilled, using the fraction 34–36° C.

Chloroform. 25. Chloroform shall be pure and freshly distilled.

Carbon Tetrachloride. 26. Carbon tetrachloride shall be pure and freshly distilled.

27. Reagents not otherwise specified shall be chemically pure. Water shall be distilled.

VIII. ANALYSES.

Acetone Extract. 28. Extract continuously with 60 cc. of acetone for 8 hours, two 2-g. samples that have been prepared within 24 hours. Unite the extracts in a weighed flask, using hot chloroform to rinse the flasks. Distill off the reagents and dry the flask and contents for 4 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down the side of the flask.

Unsaponifiable Matter. 29. Add to the acetone extract 50 cc. of alcoholic KOH solution, boil under a reflux condenser for 2 hours, and evaporate to dryness, removing all alcohol. Add 10 cc. of water and 20 cc. of ether; heat until the wax, etc., are in solution, cool, transfer to a separatory funnel, wash out the flask with warm water and then cool, finally with two 20-cc. portions of ether. The water volume should be 100 cc. and the ether at least 40 cc. Shake vigorously for 2 minutes, and allow the solutions to separate thoroughly. Draw off the aqueous solution into a second funnel, leaving in the first funnel the ethereal solution and any flocculent material that may be present. Again rinse the flask with 20 cc. of ether and add it to the aqueous solution; shake vigorously for 2 minutes, and when separated draw off the aqueous solution and unite in the first funnel the ethereal solutions and any flocculent material. Repeat, shaking with 20-cc. portions of ether until the extraction is complete, using at least 120 cc. of ether. Wash the flask and the funnel, from which the ethereal solution has been taken, with water, until they are free from alkali, subsequently using this wash water to wash the ethereal solution.

Continue washing with water until it has been washed twice after it shows no alkaline reaction. Retain with the ethereal solution any flocculent material. Filter the ethereal solution from the flocculent material, through a small pellet of extracted cotton, into a weighed flask, washing first with ether and subsequently with hot chloroform, using this to rinse the original flask and both separatory funnels. Evaporate the solvents and dry the extract to constant weight at 95 to 100° C.; desiccate until cool and weigh.

Hydrocarbons A.

30. Add 50 cc. of absolute alcohol to the unsaponifiable material and warm until solution is as complete as possible. Cool the solution to -4 or $-5°$ C. and maintain at this temperature for 1 hour by packing the flask in a mixture of ice and salt. Filter out the waxy hydrocarbons, using a funnel packed with ice and salt, and apply suction if necessary. Wash the flask and filter with about 25 cc. of 95-per-cent alcohol, which has been previously cooled in the same temperature. Catch the filtrate in a flask which is afterwards cooled to -4 or $-5°$ C. to make sure that all possible waxy hydrocarbons have been removed, and refilter if necessary. Dissolve the residue on the filter paper with hot chloroform, into the original flask. Evaporate the chloroform and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Hydrocarbons B.

31. Evaporate the alcohol from the flask containing the alcoholic soluble unsaponifiable material, add 25 cc. carbon tetrachloride and transfer to a separatory funnel. Shake with concentrated H_2SO_4, drain off the discolored acid and repeat with fresh portions of acid until there is no longer any discoloration. After drawing off all the acid, wash the carbon tetrachloride solution with repeated portions of water until all traces of acid are removed. Transfer the carbon tetrachloride solution to a weighed flask; evaporate off the solvent and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Free Sulfur.

32. Add 2 g. KNO_3 to the aqueous solution and washings from the ethereal separation of the unsaponified material. Evaporate to dryness in a silver or nickel dish and heat to quiet fusion, avoiding contamination with sulfur fumes. Transfer with water to an evaporating dish, acidify with HCl, evaporate to dryness, and dehydrate silica. Add 2 cc. of concentrated HCl, take up in water, filter and wash, making a volume of 200 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate the sulfur.

Chloroform Extract.

33. Extract continuously the residues from both of the acetone extractions (without necessarily removing the acetone that may be

on them) for 4 hours with 60 cc. of chloroform, unite the extractions in a weighed flask, using hot chloroform to rinse the flasks. Distill off the solvent and dry the flask and contents for 2 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 1-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down the side of the flask. (If it is needful to wait after the acetone extraction, before starting the chloroform extraction, the sample must be kept in a vacuum of at least 50 mm. of mercury.)

Alcoholic KOH Extract.

34. Dry the residue from the chloroform extraction at 50 to 60° C. until odor of chloroform can no longer be detected, unite residues from the two 2-g. samples in a 200-cc. Erlenmeyer flask. Add 100 cc. of alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution by decantation through an 11-cc. hardened filter paper into a beaker and wash twice, using each time 25 cc. of hot absolute alcohol and then wash thoroughly with hot water. Wash any rubber on the filter paper back into the original flask and reserve this for the determination of the rubber hydrocarbons. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. of 5 *N* HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool, add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portions of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Rubber Hydrocarbons.

35. Add to the flask containing the rubber residue from the alcoholic KOH extraction, sufficient water to make the total volume of the solution 125 cc. and then add 25 cc. of concentrated HCl. Heat for an hour at 97 to 100° C. Decant the supernatant liquid through a hardened filter paper on a Buchner funnel 7 cm. in diameter, using suction; wash the residue with 25 cc. of hot water and decant. (While a Buchner funnel is recommended, it is permissible to use an 11-cm. hardened filter paper with platinum cone, in a 60-deg. funnel.)

Perform this entire treatment with water and HCl three times and save the first and second decantations for the "organic matter" test described in Section 40. The rubber at this stage should be white and practically free from black specks of undissolved fillers; if not, continue the acid treatment until the black specks disappear. (If carbon is present, all the particles of rubber will be grayish, bluish, or black, depending on the form and quantity of carbon used. Black specks in light particles of rubber usually indicate the presence of lead sulfide which must be removed to prevent the formation of lead sulfate on igniting the residue *C*.) Add 150 cc. of hot water to the flask and let stand on a steam bath or hot plate for half an hour and decant through the filter paper, repeating until washings are free from chlorides. (See Section 40.) Transfer all the rubber in the flask to the filter paper and dry as much as possible by suction. Wash the rubber with 50 cc. of 95-per-cent alcohol, using suction. Transfer the entire residue to a weighing bottle. Dry at 95 to 100° C. for an hour, cool in a vacuum desiccator under reduced pressure and weigh. Dry for 30 minutes, cool and weigh, repeating this process until either constant weight is reached or the weight starts to increase. Let this weight be represented by *C*. Determine the ash (*E*) on a portion (*D*) of this residue (*C*) and sulfur (*H*) on the remaining portion (*G*). Also determine the sulfur (*F*) on the ash (*E*). Perform the ash determination as described under ash in Rubber Residue and the sulfur determinations as described under Total Sulfur. Then,

$$\text{Rubber hydrocarbons} = 100\,\frac{C}{4}\left(1-\frac{H}{C}-\frac{E-F}{D}\right)$$

expressed as a percentage of the total sample.

Ash in Rubber Residue. 36. Place about 0.5 g. (*D*) of residue *C* into a weighed porcelain crucible and heat gently, gradually driving off the volatile matter. When the crucible has ceased to smoke, raise the temperature gradually to between 450 and 500° C., until all organic matter has been burned away, which is usually indicated by the ash becoming white. (An electric muffle furnace with pyrometer is recommended for this purpose.) Cool in a desiccator and weigh, the weight of ash being represented by *E* in the formula for rubber hydrocarbons. Make the sulfur test on ash by the method described in Section 37. If, however, the ash (*E*) is not over 0.08 *D*, the determination of sulfur in the ash may be omitted, and *F* assumed to be zero.

Total Sulfur. 37. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion, and then bring to quiet fusion for 15 to 20 minutes. Apply the heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put the crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate silica; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 100 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

Specific Gravity.

38. The specific gravity shall be the ratio of the weight of a given volume of the rubber to the weight of an equal volume of water, both at 20° C. Strips of the largest applicable size shall be cut from the conductor and about 5 g. used for the sample. The specific gravity shall be determined in the usual manner by means of a specific gravity bottle. Care must be taken that no air bubbles adhere to the sample.

Red Lead.

39. Dissolve 1 g. of the sample in 75 cc. of xylol at a temperature of about 100° C. When the rubber is dissolved, the absence of any red particles indicates the absence of red lead. If red particles are present, filter the solution into a Gooch crucible and wash thoroughly with benzol, acetone and alcohol successively. Remove the felt and residue to a distilling flask, add HCl, and distill over the chlorine liberated by the lead peroxide, absorbing the gas in a solution of KI and starch. Not more than 0.1 cc. of 0.1 *N* thiosulfate shall be required to titrate the iodine liberated.

Organic Filler.

40. Transfer the first and second decantations of the HCl solutions to a carefully cleaned porcleain dish and add 20 cc. of concentrated H_2SO_4. Place the dish on a steam bath or hot plate to drive off water and HCl. A pronounced charring of the residue indicates the presence of organic matter soluble in water or hydrolyzed by HCl. Examine the filter paper and rubber while decanting the acid solution and washing free of chlorides. Some types of organic fillers not removed by water and HCl would be plainly visible at this point. Place a small portion of residue *C* under a microscope and examine for fibrous and other characteristic organic material. If organic fillers are indicated and not clearly proved by this test, place 1 g. of the original sample in a beaker, add 50 cc. of xylol and heat on a hot plate until the rubber is dissolved. Decant the xylol solution and wash

the residue with ether several times by decantation. Dry the residue and examine under the microscope.

IX. DEFINITIONS OF TERMS DESCRIBING COMPONENTS OF ACETONE EXTRACT.

41. *Organic Extract.*—The difference between the Acetone Extract and the Free Sulfur. **Organic Extract.**

42. *Saponifiable Acetone Extract.*—The difference between the Organic Extract and the Unsaponifiable Material. **Saponifiable Acetone Extract.**

43. *Total Waxy Hydrocarbons.*—The sum of the Hydrocarbons A and B. **Waxy Hydrocarbon.**

44. *Unsaponifiable Resins.*—The difference between the Unsaponifiable Material and the Waxy Hydrocarbons. **Unsaponifiable Resins.**

X. CHECK ANALYSES.

45. Specific gravity determinations shall check within 0.01. The other duplicate determinations shall check within the following limits expressed as percentages of the original sample. **Checks.**

DETERMINATION.	CHECK.
Acetone extract	0.10
Saponifiable acetone extract	0.10
Unsaponifiable resins	0.10
Waxy hydrocarbons	0.10
Free sulfur	0.05
Chloroform extract	0.10
Alcoholic potash extract	0.10
Rubber hydrocarbons	0.20
Total sulfur	0.10

XI. INTERPRETATION.

46. The rubber shall be considered to be the sum of the rubber hydrocarbons, saponifiable acetone extract, unsaponifiable resins and chloroform and alcoholic potash extracts, expressed as percentages. If the chloroform extract is over 3.0 per cent of the rubber so calculated, subtract the excess from the rubber. If the KOH extract is over 1.8 per cent of the rubber as first calculated, subtract this excess also from the rubber. **Interpretation.**

XII. STATEMENT OF RESULTS.

47. The results of the analysis shall be stated in the following form: **Statement of Results.**

	PER CENT.
Acetone extract	....
Saponifiable acetone extract	....
Unsaponifiable resins	....
Waxy hydrocarbons	....
Free sulfur	....
Chloroform extract	....
Alcoholic potash extract	....
Total sulfur	....
Rubber	....
Color of acetone extract (60 cc. vol.)	....
Fluorescence in acetone extract solution (present or absent)	....
Hydrocarbons A (consistency and color	....
Hydrocarbons B (solid or liquid)	....
Color of chloroform extract (60 cc. vol.)	....
Carbon (present or absent)	....
Red lead (present or absent)	....
Specific gravity	....

II. PHYSICAL TESTS.

Scope. 48. (*a*) These tests are intended to apply to soft vulcanized rubber compounds such as are used for lining and cover of hose, belting, gloves used by electrical workers, etc.

(*b*) Only those tests which are applicable to rubber products in general have been covered. Tests which are special for only one class of material are not included since such tests more properly belong in the specifications for the particular material.

Selection and Condition of Samples. 49. (*a*) Samples shall be selected in accordance with the requirements of the specifications covering the material to be tested.

(*b*) The samples shall be taken from the finished product and shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed herein.

Age of Samples. 50. No tests shall be made within 48 hours after vulcanization unless agreed to by the manufacturer.

Temperature. 51. (*a*) The temperature of the surrounding air where samples of rubber are being tested shall not be less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.).

(*b*) The samples shall be kept at a temperature within these limits for at least 3 hours immediately before being tested.

Separation of Rubber. 52. When the tests to be made require the separation of the rubber from cotton fabric, it shall be done without the use of gasoline if possible. If it is necessary to use gasoline, it shall be of a grade which distills below 239° F. (115° C.) and the specimen shall be allowed to rest at least one hour before being tested.

(*A*) *Tensile Strength, Elongation and Set Tests.*

XIII. TENSION TESTING APPARATUS.

Type. 53. (*a*) Tensile strength and elongation tests shall be made on a power-driven apparatus, preferably of the inclination-balance or pendulum type. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture took place, and provision is made to prevent recoil of the spring.

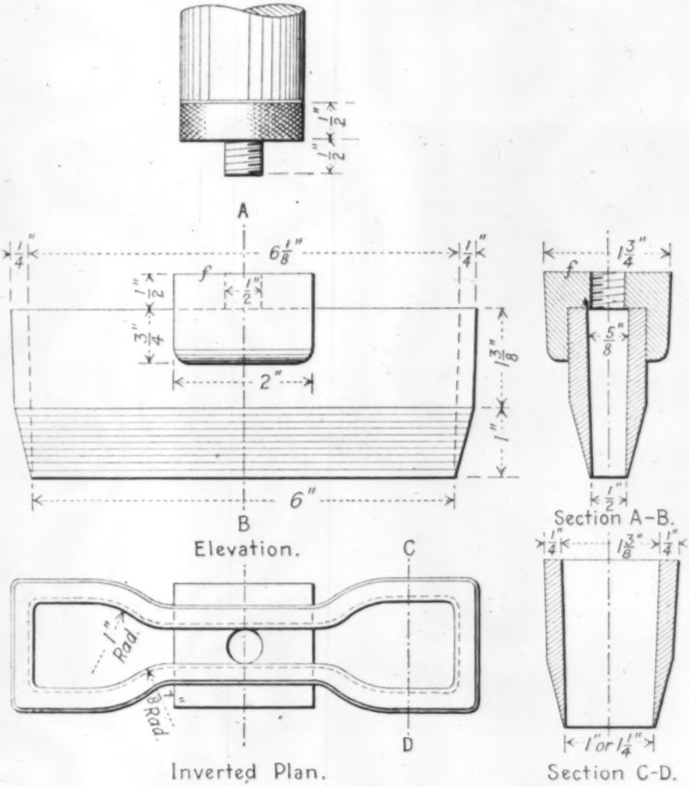

1/2"
1/2"
A
1/4"
6 1/8"
1/4"
f
1/2"
1/2"
3/4"
2"
1 3/8"
1"
6"
B
Elevation.
C
1" Rad.
1/8 Rad.
D
Inverted Plan.
1 3/4"
f
5/8"
1/2"
Section A-B.
1/4"
1 3/8"
1/4"
1" or 1 1/4"
Section C-D.

FIG. 4.—Die for ½ by 2-in. Specimens.

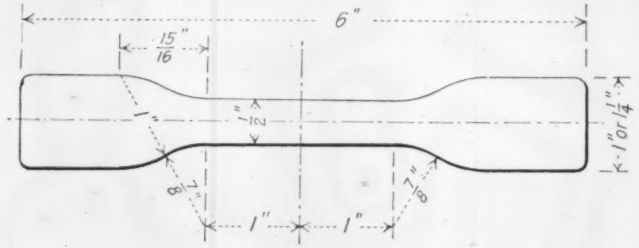
Accuracy. (*b*) The accuracy of the apparatus shall be such that the readings obtained are correct within ±1 per cent.

Grips. (*c*) The grips which hold the specimen in the testing machine shall be of any desired type which tightens automatically and exerts a uniform pressure across the width of the specimen proportional to the applied tension.

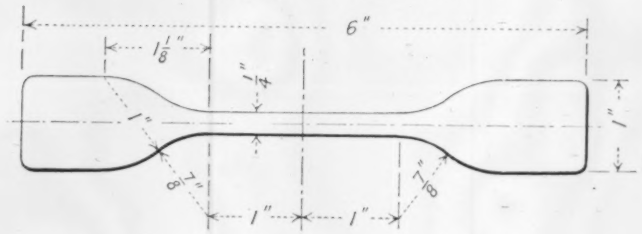
Rate. (*d*) The rate of separation of the grips shall be uniform at all times and approximately 20 in. per min.

XIV. TEST SPECIMENS.

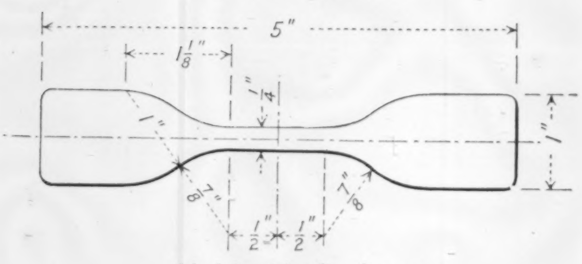
Shape. 54. (*a*) Unless otherwise prescribed in the specifications for the material being tested, the specimens for tensile strength and elongation tests and those for set tests shall be stamped out with a steel die constructed substantially in accordance with Fig. 4, the specimen to have a reduced section at the center 2 in. long and 0.5 in. wide, 2 in. long and ¼ in. wide or 1 in. long and ¼ in. wide as shown in Fig. 5. The largest specimen that can be readily cut from the sample shall be used.



(*a*) ½ by 2-in. Specimen.



(*b*) ¼ by 2-in. Specimen.



(*c*) ¼ by 1-in. Specimen.

Fig. 5.—Tensile Strength and Elongation Test Specimens.

Buffing. (*b*) All backing and deep corrugations as in seamless woven or braided hose shall be carefully removed by means of a suitable grinding machine and without causing excessive heating. It is recommended that a grinder similar to that shown in Fig. 6 be used.

At least one hour shall elapse between the buffing and testing of the specimen.

Gage Marks. (*c*) Two parallel lines perpendicular to the axis of the specimen shall be marked on the reduced section, one on each side of the center and 0.5 in. or 1 in. therefrom as required. The marks shall be as narrow as possible consistent with legibility.

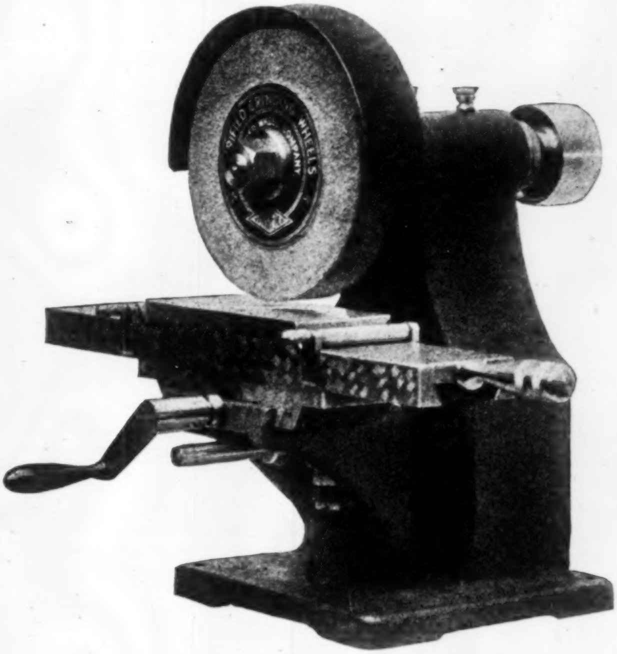


FIG. 6.—Grinder.

Dimensions. (*d*) The thickness shall be measured with a micrometer graduated to 0.001 in. having circular shoes 0.24 to 0.26 in. in diameter and with a pressure on the specimen of not less than 8 oz. nor more than 10 oz.

The minimum thickness and width between the gage marks shall be taken in calculating the area to be used in determining the tensile strength of the specimen.

Number of Test Specimens. 55. (*a*) One specimen per sample shall be tested for tensile strength and elongation. If either the tensile strength or the elongation is below the specified value, two additional specimens shall be tested. If either specimen falls below the specified value for either tensile strength or elongation, the material represented by the sample from which the specimens were taken shall be considered to have failed to meet the specifications.

(*b*) One specimen per sample shall be tested for set. If it fails to meet the specifications, the procedure shall be the same as in Section 55 (*a*).

(*c*) If a specimen breaks outside of the gage marks in the tensile strength and elongation tests, or is found to have been defective in either the tension test or the set test, it shall be discarded and the test repeated on a new specimen.

XV. PROCEDURE.

Tensile Strength and Elongation. 56. (*a*) With the specimen gripped evenly in the grips of the testing machine, the grips are separated at a uniform rate of approximately 20 in. per min. until rupture occurs. The distance between the gage marks shall be noted continuously so that at the instant of rupture the distance is known within 0.1 in.

The load at rupture in pounds divided by the minimum original area of the specimen at the reduced section in square inches shall be taken as the tensile strength in pounds per square inch. The distance between the gage marks at rupture in inches to the nearest 0.1 in., minus the original gage length, shall be taken as the elongation.

Set. (*b*) The specimen shall be stretched until the distance between the gage marks is the prescribed amount, held stretched this amount for the prescribed length of time and then released. After the lapse of the prescribed time, the distance between the gage marks shall be measured to the nearest 0.02 in. The difference between the final distance and the original distance, divided by the original distance and expressed as percentage, shall be taken as the set.

(*B*) *Friction Tests.*

XVI. TEST SPECIMENS.

Fire Hose. 57. (*a*) The test specimens shall be pieces of the hose 2 in. in length accurately cut from the sample with a sharp tool which will leave clean edges. These rings shall then be slit in the lengthwise direction of the hose and laid out flat. One-quarter inch of the rubber lining shall be carefully and cleanly trimmed off on each side without injuring the fabric leaving a strip of rubber lining 1½ in. in width undisturbed on a strip of cover 2 in. in width.

(*b*) The test specimens shall be pieces of the hose 1 in. in length accurately cut from the sample with a sharp tool which will leave clean edges. They shall be tested in the ring form. **Other Types of Hose.**

(*c*) A strip 6 in. in length by 1 in. in width shall be cut from the sample of belting with a sharp tool which will leave clean edges. Two test specimens of two plies each shall be taken from this strip and tested separately. **Belting.**

58. One specimen per sample shall be tested for friction. If the result is below the specified value, two additional specimens shall be tested. If either of these specimens falls below the specified value, the material represented by the sample from which the specimens were taken shall be considered to have failed to meet the specifications. **Number of Test Specimens.**

XVII. PROCEDURE.

59. (*a*) The plies, the friction between which is to be tested, shall be separated by hand at one end of the specimen a sufficient distance to permit attaching the grips. **Fire Hose and Belting.**

With one separated end clamped in a stationary grip, the other separated end is clamped in a freely suspended grip hanging vertical and to which the prescribed weight is attached with suitable provision for supporting and releasing it slowly without jerking. The distance through which separation takes place shall be noted for a period of 10 minutes if possible. The friction shall be taken as the rate obtained by dividing the total distance separated in inches (to nearest 0.05 in.) by the elapsed time in minutes (to the nearest 0.017 min., that is, one second.)

(*b*) The test specimen shall be placed on a mandrel having a diameter equal to the nominal diameter of the hose. The cover shall be cut through in the lengthwise direction of the hose and enough of one end separated from the rubber to permit attaching a grip. With the mandrel held stationary, the prescribed weight shall be attached to the grip and the test carried out as prescribed for fire hose in Paragraph (*a*). **Other Types of Hose.**

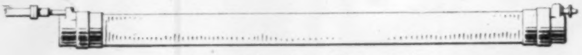
(*C*) *Hydrostatic Tests of Hose.*

60. Pressure tests shall be made with water by means of a pump or by means of an accumulator system. The pressure shall be increased at a constant rate of 300 lb. per min. and shall be measured with a calibrated gage. **Application and Measurement of Pressure.**

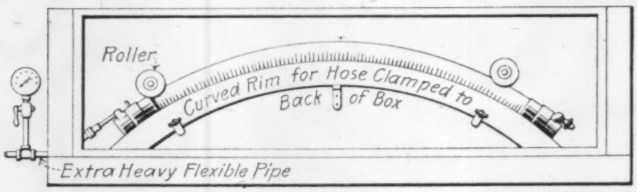
61. (*a*) *Tests of Each Length.*—The hose shall be stretched on a plane surface in a straight line and connected to the water line or pump and filled with water, the air being allowed to escape through **Fire Hose.**

an air cock. When the hose is filled with water the air cock shall be closed, a pressure of 10 lb. per sq. in. applied and the length carefully measured.

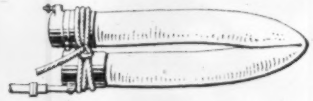
The pressure shall then be increased to the prescribed value and held for the prescribed period. While still under this pressure the length shall be measured and the amount of twist, warp and rise shall be determined.



Test 1. Hose Straight.


Roller
Curved Rim for Hose Clamped to Back of Box
Extra Heavy Flexible Pipe

Test 2. Hose Curved on Radius of 2¼ feet.



Test 3. Hose Kinked,
Ends Tied Together.

FIG. 7.—Apparatus for Pressure Test.

(*b*) *Tests of Samples.*—The arrangement of the sample for various proof tests—straight, curved and kinked—shall be substantially as indicated in Fig. 7 except that in the kink test of a full length, the two parts of the hose made by the kink shall be tied together at a point 18 in. from the kink.

TENTATIVE SPECIFICATIONS
FOR
IMPERFECTIONS AND TOLERANCES FOR 60-IN. $17\frac{1}{4}$-OZ. SQUARE-WOVEN BUILDER FABRIC.
(MADE OF YARN NOT LESS THAN 8 PLY.)[1]

Serial Designation: D 122 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

IMPERFECTIONS.

(*A*) *Classification.*

1. Imperfections shall be those defects in material and workmanship which are in large measure capable of reduction and control by supervision and which, though important, do not form an essential element of the specifications. They may be classified as such deviations from the qualitative characteristics of the perfect fabric as shall materially depreciate its commercial value.

Classification. 2. The imperfections as defined may be segregated into three groups for practical purposes: Major defects, minor defects, and special defects, as follows:

MAJOR DEFECTS.

Thick and Thin Places
Missing Warp Thread
Pucker
Bad Start-up

MINOR DEFECTS.

Thick and Thin Places
Slack and Tight Threads
Slugs
Sewed Thread
Knots
Mispick or Broken Pick
Float
Reed Mark
Split or Chafed Yarn
Dirty Yarn
Wrong Ply, Warp Thread
Wrong Draw

SPECIAL DEFECTS.

Oil Spots
Mixed Filling, Inferior Grade
Smashes
Imperfect Selvage
Wrong Ply, Filling Threads

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

(*B*) *Nomenclature and Definitions.*

Major Defects.

3. *Major Defects.*—

(*a*) *Thick and Thin Places.*—Places where count varies ten per cent or over from the specified count for one inch or more.

(*b*) *Missing Warp Thread.*—Place where a portion of the warp thread is missing.

(*c*) *Pucker* (*Puff or Blister*).—A series of six or more tight or slack warp threads.

(*d*) *Bad Start-up.*—Is caused by removing filling thread, usually resulting in chafed or tight and loose warp threads, thin selvage or excessive bow, or any combination of them.

Minor Defects.

4. *Minor Defects.*—

(*a*) *Thick and Thin Places.*—Places where the count varies ten per cent or over from the specified count for less than one inch.

(*b*) *Slack and Tight Warp or Filling Threads.*—Threads having too little or too much tension.

(*c*) *Slug.*—A bunch of lint entangled in the fabric.

(*d*) *Sewed Thread.*—A thread interwoven by hand to correct a defect.

(*e*) *Knot.*—A joining of portions of a full-ply thread by a knot.

(*f*) *Mispick or Broken Pick.*—A missing or partly missing pick causing a streak across the width of the fabric.

(*g*) *Float.*—Incorrect interlacing of warp and filling threads.

(*h*) *Reed Mark.*—Irregularity in warp count due to a sprung reed.

(*i*) *Split or Chafed Yarn.*—One or more ends of ply yarn broken and chafed into a bunch.

(*j*) *Dirty Yarn.*—Requires no definition.

(*k*) *Wrong Ply Warp Thread.*—Requires no definition.

(*l*) *Wrong Draw.*—Is caused by drawing a warp thread through the wrong harness and appears in the fabric as a streak lengthwise due to the filling floating over more than one warp thread.

Special Defects.

5. *Special Defects.*—

(*a*) *Oil Spots.*—Requires no definition.

(*b*) *Mixed Filling Yarn of Inferior Grade.*—Requires no definition.

(*c*) *Smash.*—Broken warp threads caused by the shuttle getting caught in the shed during weaving.

(*d*) *Imperfect Selvage.*—Tight, loose, cut, weak, or nicked selvage.

(*e*) *Wrong Ply Filling Thread.*—Requires no definition.

(*C*) *Scoring System of Grading.*

Grading.

6. Scoring shall be based on major and minor defects, all major defects counting alike, and all minor defects counting alike.

7. On a basis of four major defects or twenty minor defects, or any combination of these, being permissible in a roll of 100 sq. yd., the scoring shall be as follows:

Deduct 25 from 100 for each major defect in 100 sq. yd.
Deduct 5 from 100 for each minor defect in 100 sq. yd.
Add the remainder, which sum shall be the score.

8. Any roll of 100 sq. yd. giving a sum of 100 or above shall be graded *Grade A*.

Any roll of 100 sq. yd. giving a sum below 100 shall be graded *Grade B*.

9. (*a*) *Grade A* shall be understood to be first class (entirely satisfactory delivery).

(*b*) *Grade B* shall be subject to adjustment or rejection.

Example.—A roll of 100 sq. yd. contains 2 major, and 6 minor defects.

$$\begin{array}{r} 100 \\ -50 \\ \hline 50 \end{array} \qquad\qquad \begin{array}{r} 100 \\ -30 \\ \hline 70 \end{array}$$

$$50+70=120 \text{ (Grade } A\text{)}$$

Example.—A roll of 100 sq. yd. contains 3 major and 15 minor defects.

$$\begin{array}{r} 100 \\ -75 \\ \hline 25 \end{array} \qquad\qquad \begin{array}{r} 100 \\ -75 \\ \hline 25 \end{array}$$

$$25+25=50 \text{ (Grade } B\text{)}$$

10. Special defects shall be subject to allowance or adjustment between the manufacturer and consumer and are not to be included in the scoring.

TOLERANCES.

Tolerances.

11. Tolerances shall be the limit within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable limits of the quantitative characteristics of the fabric as defined in the specifications. The following tolerances are based upon the

Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

Width. 12. (*a*) No individual measurement made to determine the width of the fabric shall be more than 2 per cent over or 1 per cent under the specified average width.

(*b*) The average width determined by measurements shall be not more than 1 per cent over nor 0.5 per cent under the specified average width.

Weight per Square Yard. 13. The weight of the fabric,determined by test shall be not less than 16.9 oz. nor more than 17.6 oz.

Count per Inch. 14. The count per inch determined by test shall be not more than 0.2 ends over nor 0.4 ends under the specified count, and not more than 1 pick over or under for the filler.

Bow. 15. The bow determined by test shall be not more than $\frac{3}{8}$ in. over or under the bow specified.

NOTE.—Bow should be ascertained by five determinations made throughout the roll commencing at least 10 yd. from either end of the roll.

Off-square. 16. The allowable variation in the off-square of the fabric shall be 3 per cent over or under the specified percentage off square.

Gage. 17. The average thickness determined by test shall not vary more than 0.002 in. under or over the specified thickness in fabrics made of combed staple, and not more than 0.003 in. under or over the specified thickness in fabrics made from carded staple.

Tensile Strength. 18. The average tensile strength of the warp and the average tensile strength of the filling found by test shall be not less than the specified tensile strength.

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[1] 1921 Book of A.S.T.M. Standards.

TENTATIVE METHODS OF TESTING TEXTILES.[1]

Serial Designation: D 76 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1920; REVISED, 1922.

Type of Machine.

1. Textile testing machines shall be of the inclination balance or pendulum type.

Testing Machine Capacity.

2. In selecting the proper capacity of testing machine for a given fabric, it is recommended that the maximum capacity of the machine shall conform to the following:

BREAKING STRENGTH OF FABRIC, LB.	MAXIMUM MACHINE CAPACITY, LB.
0 – 25	50
10 – 50	100
20 – 100	150
50 – 200	300
50 – 300	400
250 – 650	800

Angle of Pendulum.

3. The maximum angle of swing of the pendulum shall be 40 deg. from the vertical.

Rate of Loading.

4. The rate of loading in textile testing machines shall be 250 lb. per 1 in. of traverse of the head jaw.

Type of Jaw.

5. The jaws in textile testing machines shall be of the flat anvil type, both anvils being free to swing on a horizontal axis. The anvil faces shall be smooth and no friction cloth shall be used. The anvils shall be closed at a uniform and invariable pressure by means of an eccentric and lever.

Crimp.

6. Crimp shall be defined as the difference in distance between any two points on a yarn in a fabric and the same two points after the yarn has been removed and straightened. This difference shall be reduced to percentage of the yarn length as it lies in the fabric.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

NOTE.—"Crimp" shall not be confused with "take-up" which is the percentage difference between the yarn length after straightening and the yarn length as it lies in the fabric based on the straightened yarn length. The threads for the "take-up" test shall be straightened with the same machine used for the "crimp" test, but for this test it shall be equipped with an extra scale on the dial, in which case the scale shall be plainly marked "crimp" and "take-up."

Off-square.

7. The percentage of warp crimp minus the percentage of filling crimp shall be defined as the off-square of the fabric.

Method of Determining Crimp in Tire Fabric.

8. Threads for crimp test of tire fabric shall be taken from the inside edge of test piece as near the center line of the roll as possible. Threads for crimp test shall be laid out by marking across them in the fabric parallel lines not less than 6 in. apart. An even number of threads not less than four in number shall be taken for each warp and each filling test. These threads shall be ravelled from the fabric after marking, allowing about 2 in. extra on each end of the threads beyond the marks. The threads shall then be straightened by a machine which applies a constant load of 75 g. and the length between the original markings shall then be read in terms of the yarn length as it lay in the fabric. The machine shall be equipped with a dial or scale so arranged as to read the percentage crimp directly.

TENTATIVE METHODS OF TESTING COTTON FIBERS.[1]

Serial Designation: D 152 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922.

Group Strength Test Method.

1. The strength shall be the strength of a group of fibers expressed in terms of a weight equal to a unit weight of 20s yarn.

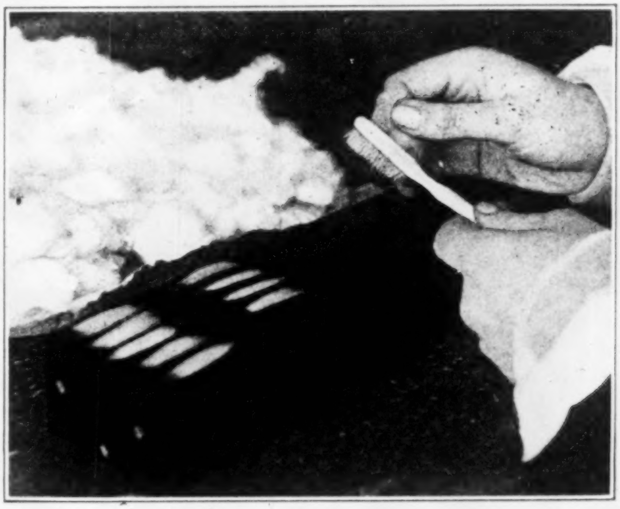

FIG. 1.—Brushing to Remove Short Fibers.

I. PREPARATION OF SAMPLE.

Preparation of Sample.

2. (*a*) The cotton shall be pulled down in the customary manner of a cotton classer which produces fibers that are essentially parallel.

(*b*) The fibers shorter than $\frac{7}{8}$ in. shall be removed by means of a small brush. See Fig. 1.

(*c*) The group or bundle of fibers shall be cut to equal $\frac{7}{8}$ in. to assure all fibers being $\frac{7}{8}$ in. long. See Fig. 2.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

(*d*) The bundles shall be weighed, each bundle to weigh approximately 0.004 g.

(*e*) The ends of each group shall be cemented with collodion to prevent the fibers from slipping. See Fig. 3.

Five bundles shall be used.

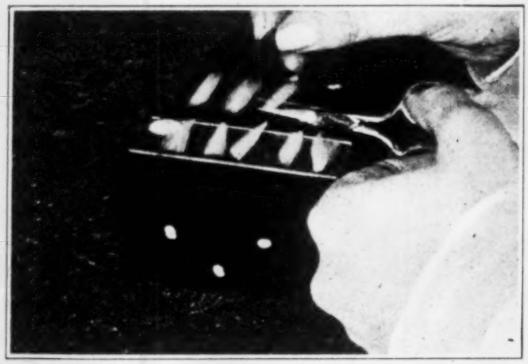

FIG. 2.—Cutting Fibers to Equal Length.

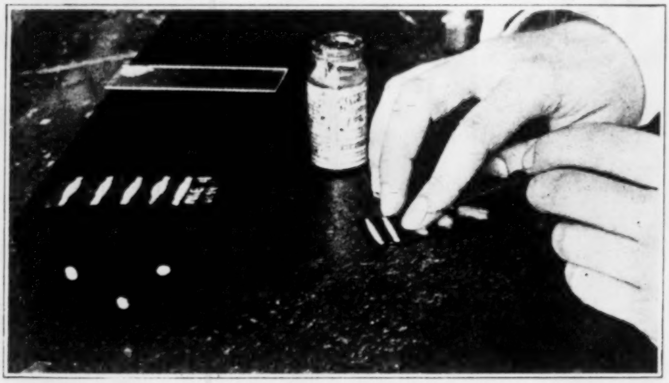

FIG. 3.—Cementing Ends of Fiber Groups.

II. PROCEDURE.

Moisture. Condition. 3. The samples shall be exposed to a relative humidity of 70 per cent for two hours before weighing and before testing for strength.

Machine. 4. The conventional inclination balance testing machine of 10-lb. capacity shall be used with the clamp moving at the rate of 12 in. per minute.

The distance between the clamps shall be $\frac{1}{2}$ in.

The clamps shall be flat, of the metal or rubber insert type, $\frac{1}{2}$ in. in width and $\frac{1}{2}$ in. in depth.

Result. 5. The result shall be expressed in terms of an equivalent weight of 20s yarn by the formula:

$$\text{Strength in ounces of cotton equal to unit of 20s yarn} = \frac{\text{Sum of Strengths in pounds} \times 16 \times 453.6 \times 7}{\text{Sum of Weights in grams} \times 840 \times 20 \times 36 \times 8}$$

TENTATIVE DEFINITIONS OF TERMS RELATING TO TEXTILE MATERIALS.[1]

Serial Designation: D 123 – 22 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922.

(*A*) *Mechanical Fabric.*

1. The term "Mechanical Fabric" shall be understood to mean fabric manufactured to be used as an intermediate product in the making of some mechanically constructed article.

2. Mechanical fabrics shall be referred to by the following descriptive nomenclature:

(*a*) A word or phrase generally descriptive of the appearance of the material, or the use to which it is put.

(*b*) Weight in ounces per square yard. The words "oz. sq. yd." are to be written after the weight. To avoid confusion in regard to weight of material, it is suggested that immediately succeeding the square yard weight, the weight of the material on whatever basis may have been used previous to the adoption of these standards be inserted in brackets. Table I gives the conversion values of linear yard weight to square yard weight.

(*c*) Width in inches.

(*d*) Count, giving first the ends, and second the picks per inch.

Example: Hose Duck, 9 oz. sq. yd. [40 in. 10 oz.], 48 in., 28 by 18.

3. The following is a partial list of mechanical fabrics in general use:

Tire Builder Fabric.—A square woven fabric having usually 11-ply yarn in both warp and filling.

Tire Cord Fabric.—A fabric consisting of hawser cord yarn in the warp, with single yarn filling at intervals to keep warp threads together.

Hose Duck.—A soft, plain-weave duck of plied yarns not finer than No. 8, made in weights from 10 to 24 oz. to the 40-in. width. When made of finer yarn than No. 8, it is classed as Special Hose Duck.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. R. T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

TABLE I.—CONVERSION TABLE OF LINEAR YARD WEIGHT TO SQUARE YARD WEIGHT OF FABRIC.

Weight, oz.	Width, in.																														
	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
8	9.60	9.29	9.00	8.73	8.47	8.23	8.00	7.78	7.58	7.38	7.20	7.02	6.86	6.70	6.55	6.40	6.26	6.13	6.00	5.88	5.76	5.65	5.54	5.43	5.33	5.24	5.14	5.05	4.97	4.88	4.80
9	10.80	10.45	10.13	9.82	9.53	9.26	9.00	8.76	8.53	8.31	8.10	7.90	7.71	7.53	7.36	7.20	7.04	6.89	6.75	6.61	6.48	6.35	6.23	6.11	6.00	5.89	5.79	5.68	5.59	5.49	5.40
10	12.00	11.61	11.25	10.91	10.59	10.29	10.00	9.73	9.47	9.23	9.00	8.78	8.57	8.37	8.18	8.00	7.83	7.66	7.50	7.35	7.20	7.06	6.92	6.79	6.67	6.55	6.43	6.32	6.21	6.10	6.00
11	13.20	12.77	12.38	12.00	11.65	11.31	11.00	10.70	10.42	10.15	9.90	9.66	9.43	9.21	9.00	8.80	8.61	8.43	8.25	8.08	7.92	7.76	7.62	7.47	7.33	7.20	7.07	6.95	6.83	6.71	6.60
12	14.40	13.94	13.50	13.09	12.71	12.34	12.00	11.68	11.37	11.08	10.80	10.54	10.29	10.05	9.82	9.60	9.39	9.19	9.00	8.82	8.64	8.47	8.31	8.15	8.00	7.85	7.71	7.58	7.45	7.32	7.20
13	15.60	15.10	14.63	14.18	13.76	13.37	13.00	12.65	12.32	12.00	11.70	11.41	11.14	10.88	10.64	10.40	10.17	9.96	9.75	9.55	9.36	9.18	9.00	8.83	8.67	8.51	8.36	8.21	8.07	7.93	7.80
14	16.80	16.26	15.75	15.27	14.82	14.40	14.00	13.62	13.26	12.92	12.60	12.29	12.00	11.72	11.45	11.20	10.96	10.72	10.50	10.29	10.08	9.88	9.69	9.51	9.33	9.16	9.00	8.84	8.69	8.54	8.40
15	18.00	17.42	16.88	16.36	15.88	15.43	15.00	14.60	14.21	13.85	13.50	13.17	12.86	12.56	12.27	12.00	11.74	11.49	11.25	11.02	10.80	10.59	10.38	10.19	10.00	9.82	9.64	9.47	9.31	9.15	9.00
16	19.20	18.58	18.00	17.45	16.94	16.46	16.00	15.57	15.16	14.77	14.40	14.05	13.71	13.40	13.09	12.80	12.52	12.26	12.00	11.76	11.52	11.29	11.08	10.87	10.67	10.47	10.29	10.11	9.93	9.76	9.60
17	20.40	19.74	19.13	18.56	18.00	17.49	17.00	16.54	16.11	15.69	15.30	14.93	14.57	14.23	13.91	13.60	13.30	13.02	12.75	12.49	12.24	12.00	11.77	11.55	11.33	11.13	10.93	10.74	10.55	10.37	10.20
18	21.60	20.90	20.25	19.64	19.06	18.51	18.00	17.51	17.05	16.62	16.20	15.80	15.43	15.07	14.73	14.40	14.09	13.79	13.50	13.22	12.96	12.71	12.46	12.23	12.00	11.78	11.57	11.37	11.17	10.98	10.80
19	22.80	22.06	21.38	20.73	20.12	19.54	19.00	18.49	18.10	17.54	17.10	16.68	16.29	15.91	15.55	15.20	14.87	14.55	14.25	13.96	13.68	13.41	13.15	12.91	12.67	12.44	12.21	12.00	11.79	11.59	11.40
20	24.00	23.23	22.50	21.82	21.18	20.57	20.00	19.46	18.95	18.46	18.00	17.56	17.14	16.74	16.36	16.00	15.65	15.32	15.00	14.69	14.40	14.12	13.85	13.58	13.33	13.09	12.86	12.63	12.41	12.20	12.00
21	25.20	24.39	23.63	22.91	22.24	21.60	21.00	20.43	19.89	19.38	18.90	18.44	18.00	17.58	17.18	16.80	16.43	16.09	15.75	15.43	15.12	14.82	14.54	14.26	14.00	13.75	13.50	13.26	13.03	12.81	12.60
22	26.40	25.55	24.75	24.00	23.29	22.63	22.00	21.41	20.84	20.31	19.80	19.32	18.86	18.42	18.00	17.60	17.22	16.85	16.50	16.16	15.84	15.53	15.23	14.94	14.67	14.40	14.14	13.89	13.66	13.42	13.20
23	27.60	26.71	25.88	25.09	24.35	23.66	23.00	22.38	21.79	22.23	20.70	20.20	19.71	19.26	18.82	18.40	18.00	17.62	17.25	16.89	16.56	16.24	15.92	15.62	15.33	15.05	14.79	14.53	14.28	14.03	13.80
24	28.80	27.87	27.00	26.18	25.41	24.69	24.00	23.35	22.74	22.15	21.60	21.07	20.57	20.09	19.64	19.20	18.78	18.38	18.00	17.63	17.28	16.94	16.62	16.30	16.00	15.71	15.43	15.16	14.90	14.64	14.40
25	30.00	29.03	28.13	27.27	26.47	25.71	25.00	24.33	23.68	23.08	22.50	21.95	21.43	20.93	20.45	20.00	19.57	19.15	18.75	18.37	18.00	17.65	17.31	16.98	16.67	16.36	16.07	15.79	15.52	15.25	15.00
26	31.20	30.19	29.25	28.36	27.53	26.74	26.00	25.30	24.63	24.00	23.40	22.83	22.29	21.77	21.27	20.80	20.35	19.91	19.50	19.10	18.72	18.35	18.00	17.66	17.33	17.02	16.71	16.42	16.14	15.86	15.60
27	32.40	31.35	30.38	29.45	28.59	27.77	27.00	26.27	25.58	24.92	24.30	23.71	23.14	22.60	22.09	21.60	21.13	20.68	20.25	19.84	19.44	19.06	18.69	18.34	18.00	17.67	17.36	17.05	16.76	16.47	16.20
28	33.60	32.52	31.50	30.55	29.65	28.80	28.00	27.25	26.53	25.85	25.20	24.59	24.00	23.44	22.91	22.40	21.91	21.45	21.00	20.57	20.16	19.76	19.38	19.02	18.67	18.33	18.00	17.68	17.38	17.08	16.80
29	34.80	33.68	32.63	31.64	30.71	29.83	29.00	28.22	27.47	26.77	26.10	25.46	24.86	24.28	23.73	23.20	22.70	22.21	21.75	21.31	20.88	20.47	20.08	19.70	19.33	18.98	18.64	18.32	18.00	17.69	17.40
30	36.00	34.84	33.75	32.73	31.76	30.85	30.00	29.19	28.42	27.69	27.00	26.34	25.71	25.12	24.55	24.00	23.48	22.98	22.50	22.04	21.60	21.18	20.77	20.37	20.00	19.64	19.29	18.95	18.62	18.31	18.00
31	37.20	36.00	34.88	33.82	32.82	31.89	31.00	30.16	29.37	28.62	27.90	27.22	26.57	25.95	25.36	24.80	24.26	23.74	23.25	22.78	22.32	21.88	21.46	21.06	20.67	20.29	19.93	19.58	19.24	18.92	18.60
32	38.40	37.16	36.00	34.91	33.88	32.91	32.00	31.14	30.32	29.54	28.80	28.10	27.43	26.79	26.18	25.60	25.04	24.51	24.00	23.51	23.04	22.59	22.15	21.74	21.33	20.95	20.57	20.21	19.86	19.53	19.20
33	39.60	38.32	37.13	36.00	34.94	33.94	33.00	32.11	31.26	30.46	29.70	28.98	28.29	27.63	27.00	26.40	25.83	25.28	24.75	24.24	23.76	23.29	22.85	22.42	22.00	21.60	21.21	20.84	20.48	20.14	19.80
34	40.80	39.48	38.25	37.09	36.00	34.97	34.00	33.08	32.21	31.38	30.60	29.85	29.14	28.47	27.82	27.20	26.61	26.04	25.50	24.98	24.48	24.00	23.54	23.09	22.67	22.25	21.86	21.47	21.10	20.75	20.40
35	42.00	40.65	39.38	38.18	37.06	36.00	35.00	34.06	33.16	32.31	31.50	30.73	30.00	29.30	28.64	28.00	27.39	26.81	26.25	25.71	25.20	24.71	24.23	23.77	23.33	22.91	22.50	22.11	21.72	21.35	21.00
36	43.20	41.81	40.50	39.27	38.12	37.03	36.00	35.03	34.11	33.23	32.40	31.61	30.86	30.14	29.45	28.80	28.17	27.57	27.00	26.45	25.92	25.41	24.92	24.45	24.00	23.56	23.14	22.74	22.34	21.97	21.60

Rubber Belt Duck.—A soft, plain-weave duck of plied yarns not finer than No. 8, weight ranging from 22 to 36 oz. to 42-in. width. When made of finer yarn than No. 8, it is classed as Special Belt Duck.

Balata Belt Duck.—A closely woven fabric made of hard twisted plied yarn usually made in wide widths, the weight being based on the square yard.

Oil Belt Duck.—A closely woven fabric of plied yarns not over No. 8, made in a variety of widths, usually a 32-oz. fabric, the weight being based on the square yard.

Numbered Duck.—A plain woven fabric of plied yarns ranging from coarse to fine numbers, the weight being based on 22-in. width.

Army Duck.—A closely woven fabric of plied yarns, usually ranging between 7 to 12 oz., the weight being based on 27½-in. width.

Single Filled or Flat Duck.—A fabric made of single yarn, plain weave, the weight being based on 30-in. width.

Enameling Duck.—A plain woven fabric with laid warp and plied yarn filling, weight being based on 46½-in. width.

(*B*) *Cotton Fabrics Other than Mechanical Fabrics.*

4. *Twill.*—A weave which produces pronounced lines running diagonally across the fabric, some of which are known as follows:

(*a*) *Drills.*—A commercial term for a fabric with warp face twill usually made with three harnesses and single yarns.

(*b*) *Alberts.*—A commercial term for a fabric with filling face usually made with four or five harnesses.

(*c*) *Jeans.*—A commercial term for a fabric with warp face twill like a drill but with higher count and finer yarns.

(*d*) *Serge.*—A commercial term for a fabric of twill weave made with four harnesses 2 by 2.

(*e*) *Clay.*—A commercial term for a fabric similar to a serge but made with six harnesses 3 by 3.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative Revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS.

A. FERROUS METALS.

STANDARD SPECIFICATIONS FOR STEEL TRACK SPIKES.

(SERIAL DESIGNATION: A 65 – 18.)[1]

Section 6.—Change to read as follows:

"The spikes shall conform to the dimensions specified by the purchaser except that a variation of $\frac{1}{32}$ in. over and $\frac{1}{64}$ in. under the specified dimension of the body of the spike, and a variation of $\frac{1}{8}$ in. over and $\frac{1}{16}$ in. under the specified dimension of the head of the spike will be permitted. A variation of $\frac{1}{4}$ in. over and nothing under the specified length of the spike, measured from the under side of the head to the point, will be permitted. A variation of 1 deg. in the specified angle of the under side of the head of the spike will be permitted."

STANDARD SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL BOILER TUBES FOR LOCOMOTIVES.

(SERIAL DESIGNATION: A 28 – 21.)[1]

Section 14 (c).—Divide this section into two separate paragraphs (*c*) and (*d*) as follows, relettering Paragraph (*d*) to Paragraph (*e*):

"(*c*) The thickness of hot-finished tubes at any point shall not exceed two gages above or one gage below that specified, but in all cases the weight variation shall be within that specified in Paragraph 13 (*b*).

"(*d*) In the case of boiler tubes that are expanded and swaged, the thickness of the expanded end may be $1\frac{1}{2}$ gages lighter and the swaged end three gages heavier than the thickness specified."

STANDARD SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE.

(SERIAL DESIGNATION: A 53 – 21.)[1]

Tables I and II.—Omit the words "Black and Galvanized" now appearing under the titles of these tables.

STANDARD SPECIFICATIONS FOR AUTOMOBILE CARBON AND ALLOY STEELS.

(SERIAL DESIGNATION: A 29 – 21.)[1]

Table I.—Add to the present table the five following compositions:

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

Carbon		Manganese.		Phosphorus.	Sulfur.
Desired.	Permissible Range	Desired.	Permissible Range.	Not Over	Not Over
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.045	0.05
0.30	0.25 - 0.35	0.65	0.50 - 0.80	"	"
0.40	0.35 - 0.45	0.65	0.50 - 0.80	"	"
0.46	0.40 - 0.50	0.40	0.30 - 0.50	"	"
0.50	0.45 - 0.55	0.65	0.50 - 0.80	"	"

Table II.—In the steel of 0.15 per cent carbon, change the manganese requirement from 0.65 per cent desired (permissible range 0.50 – 0.80 per cent) to 0.45 per cent desired (permissible range 0.30 – 0.60 per cent).

Add to the present table the following composition:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.
0.50	0.45 - 0.55	0.65	0.50 - 0.80	0.04	0.045	3.50	3.25 - 3.75

Table III. (*With 1.25 per cent Nickel*).—In the steel of 0.20 per cent carbon, change the manganese from 0.65 per cent desired (permissible range 0.50 – 0.80 per cent) to 0.45 per cent desired (permissible range 0.30 – 0.60 per cent).

Add to the present table the following composition:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.	Desired.	Permissible Range.
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.04	0.04	1.25	1.00 - 1.50	0.60	0.45 - 0.75

Table III. (*With 1.75 per cent Nickel*).—Add to the present table, the two following compositions:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.	Desired.	Permissible Range.
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.04	0.04	1.75	1.50 - 2.00	1.10	0.90 - 1.25
0.45	0.40 - 0.50	0.45	0.30 - 0.60	0.04	0.04	1.75	1.50 - 2.00	1.10	0.90 - 1.25

Table III. (*With 3.50 per cent Nickel*).—Omit the compositions appearing under the heading "With 3.50 per cent Nickel" and insert the following compositions:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.	Desired.	Permissible Range.
0.12	Max., 0.17	0.45	0.30 - 0.60	0.04	0.04	3.50	3.25 - 3.75	1.50	1.25 - 1.75
0.25	0.20 - 0.30	"	"	"	"	"	"	"	"
0.35	0.30 - 0.40	"	"	"	"	"	"	"	"
0.40	0.35 - 0.45	"	"	"	"	"	"	"	"

Table IV.—Omit the present compositions and insert the following:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired	Permissible Range.
0.20	0.15 - 0.25	0.45	0.30 - 0.60	0.04	0.045	0.75	0.60 - 0.90
0.40	0.35 - 0.45	0.65	0.50 - 0.80	0.04	0.045	0.95	0.80 - 1.10
0.50	0.45 - 0.55	0.65	0.50 - 0.80	0.04	0.045	0.95	0.80 - 1.10
1.00	0.95 - 1.10	0.35	0.20 - 0.50	0.03	0.030	1.35	1.20 - 1.50

Omit the present footnote (*a*) as appearing under Table IV.

Table VII.—Omit the present compositions and insert the following:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Silicon.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.
0.50	0.45 - 0.55	0.75	0.60 - 0.90	0.045[a]	0.045	2.00	1.80 - 2.20
0.60	0.55 - 0.65	"	"	"	"	"	"

[a] Steels made by the acid process may contain 0.05 maximum phosphorus.

STANDARD SPECIFICATIONS FOR WELDED WROUGHT-IRON PIPE.

(SERIAL DESIGNATION: A 72 - 21.)[1]

Section 3 (*a*).—Change the words "puddled pig iron" to read "all pig puddled iron."

Omit the words "Black and Galvanized" from under the titles of Tables I and II.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. B. Young, Secretary of Committee A-2 on Wrought Iron, Philadelphia and Reading Railway Co., Reading, Pa.

STANDARD SPECIFICATIONS FOR WROUGHT-IRON ROLLED OR FORGED BLOOMS AND FORGINGS FOR LOCOMOTIVES AND CARS.

(Serial Designation: A 73 – 18.)[1]

Section 6 (a).—Change the requirements given in the table included in Section 6 (*a*) from their present form: namely,

Tensile strength, lb. per sq. in.	45 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 4 in., per cent	22
Reduction of area, per cent	30

to read as follows:

	Blooms.	Forgings. Classes A and B.
Tensile strength, lb. per sq. in.	45 000	45 000
Yield point, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 4 in., per cent	22	24
Reduction of area, per cent	30	33

STANDARD SPECIFICATIONS FOR FOUNDRY PIG IRON.

(Serial Designation: A 43 – 09.)[2]

A revision in the form of separate tentative specifications entitled "Specifications for Foundry Pig Iron (A 43 – 22 T)"[3] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR MALLEABLE CASTINGS.

(Serial Designation: A 47 – 19.)[4]

Section 3.—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

"The tension test specimens specified in Section 5 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	[45 000]	***50 000***
Elongation in 2 in., per cent	[7.5]	***10.0***"

Section 6 (b).—Add a sentence to read as follows:

"In case one of the retest specimens contains a flaw which results in the failure of the bar to meet the specifications, at the discretion of the inspector additional test specimens from the same oven may be tested, or test specimens may be cut from castings."

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. B. Young, Secretary of Committee A-2 on Wrought Iron, Philadelphia and Reading Railway Co., Reading, Pa.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. C. Davies, Secretary of Committee A-3 on Cast Iron, 1410 Real Estate Trust Building, Philadelphia, Pa.

[3] See p. 566.

[4] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Enrique Touceda, Secretary of Committee A-7 on Malleable Castings, Broadway, Corner Thatcher St., Albany, N. Y.

It is further recommended that the standard test specimen be modified to conform to the dimensions shown in Fig. 1. As may be noted, this changes the total length of the test specimen from 12 in. to 7½ in. and gage length from 4 in. to 2 in.

STANDARD METHODS OF CHEMICAL ANALYSIS OF PLAIN CARBON STEEL.

(SERIAL DESIGNATION: A 33 – 14.)[1]

A revision in the form of separate methods of chemical analysis, entitled "Methods of Chemical Analysis of Plain Carbon Steel (A 33 – 22 T)"[2] is intended to replace the present standard methods.

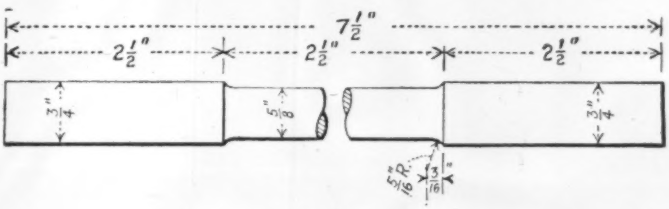

FIG. 1.

STANDARD METHODS OF CHEMICAL ANALYSIS OF ALLOY STEELS.

(SERIAL DESIGNATION: A 55 – 15.)[1]

A revision in the form of separate methods of chemical analysis, entitled "Methods of Chemical Analysis of Alloy Steels (A 55 – 22 T)"[3] is intended to replace the present standard methods.

RECOMMENDED PRACTICE FOR ANNEALING OF CARBON-STEEL CASTINGS

(SERIAL DESIGNATION: A 36 – 14.)[4]

A revision in the form of a separate recommended practice entitled "Recommended Practice for Heat Treatment of Carbon-Steel Castings (A 36 – 22 T)"[5] is intended to replace the present recommended practice.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

[2] See p. 578.

[3] See p. 600.

[4] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. H. Hall, Secretary of Committee A-4 on Heat Treatment of Iron and Steel, Taylor-Wharton Iron and Steel Co., High Bridge, N. J.

[5] See p. 643.

B. NON-FERROUS METALS.

STANDARD SPECIFICATIONS FOR HARD-DRAWN COPPER WIRE.

(SERIAL DESIGNATION: B 1 – 15.)[1]

Remove from Specifications B 1 – 15 all requirements specifically covering trolley wire only, so that the specifications will cover only round, hard-drawn copper wire.

C. CEMENT, LIME, GYPSUM AND CLAY PRODUCTS.

STANDARD SPECIFICATIONS AND TESTS FOR PORTLAND CEMENT.

(SERIAL DESIGNATION: C 9 – 21.)[2]

A revision in the form of a separate tentative specification entitled "Specifications and Tests for Compressive Strength of Portland Cement Mortars (C 9 – 16 T)"[3] is intended to become a part of the present standard specifications.

STANDARD SPECIFICATIONS FOR PAVING BRICK.

(SERIAL DESIGNATION: C 7 – 15.)[4]

Include in the specifications the following requirements for sizes of brick:

	Width, In.	Depth, In.	Length, In.
Plain wire-cut brick (vertical fiber, lugless)....	3	4	8½
" " " " " "	3½	4	8½
Repressed lug brick........................	3½	4	8½
Wire-cut lug brick (Dunn)..................	3½	3	8½
" " " "	3½	3½	8½
" " " "	3½	4	8½
Hillside lug brick (repressed)................	3½	4	8½

STANDARD SPECIFICATIONS FOR CLAY SEWER PIPE.

(SERIAL DESIGNATION: C 13 – 20.)[5]

Section 6.—Omit the last sentence. Add to the preceding sentence the words "except that in no case shall the number of specimens furnished be less than five."

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. B. Young, Secretary of Committee C-1 on Cement, Hydro-Electric Power Commission of Ontario, 8 Strachan Ave., Toronto, Ontario, Canada.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part I, p. 599 (1920).

[4] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. E. Emley, Secretary of Committee C-3 on Brick, U. S. Bureau of Standards, Washington, D. C.

[5] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. T. Hammond, Secretary of Committee C-4 on Clay and Cement Sewer Pipe, 156 Berkeley Place, Brooklyn, N. Y.

Section 7.—Insert after the word "test" in the seventh line, the words "without charge." Omit the words "without charge" in the eighth line and substitute the words "to be selected as specified in Section 6." Add a new paragraph to read as follows:

> "In addition to the foregoing requirements, failure of individual specimens to develop 75 per cent of the average crushing strength requirements shall be cause for rejection of the shipment, but the seller may cull the pipe and submit the balance of the shipment for re-test, and, if the shipment then passes all of the requirements of these specifications, it shall be accepted."

Section 11.—Omit the portion of the last sentence reading as follows:

"and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00"

Table II.—Amend Table II to read as follows:

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CLAY SEWER PIPE.

Internal Diameter, in.	Average Crushing Strength, lb. per lin. foot.		Maximum Absorption, per cent.
	Knife Edge[1] and Three-Point[2] Bearings.	Sand Bearing.[3]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8
39	3300	4710	8
42	3520	5030	8

[1] See Section 11. [2] See Section 12. [3] See Section 13.

STANDARD SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE.

(SERIAL DESIGNATION: C 14 - 20.)[1]

Section 6.—Omit the last sentence. Add to the preceding sentence the words "except that in no case shall the number of specimens furnished be less than five."

Section 7.—Insert after the word "test" in the seventh line, the words "without charge." Omit the words "without charge" in the eighth line and substitute the words "to be selected as specified in Section 6." Add a new paragraph to read as follows:

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. T. Hammond, Secretary of Committee C-4 on Clay and Cement Sewer Pipe, 156 Berkeley Place, Brooklyn, N. Y.

> "In addition to the foregoing requirements, failure of individual specimens to develop 75 per cent of the average crushing strength requirements shall be cause for rejection of the shipment, but the seller may cull the pipe and submit the balance of the shipment for re-test, and, if the shipment then passes all of the requirements of these specifications, it shall be accepted."

Section 11.—Omit the portion of the last sentence reading as follows:

"and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00"

Table II.—Amend Table II to read as follows:

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CEMENT-CONCRETE SEWER PIPE.

Internal Diameter, in.	Average Crushing Strength, lb. per lin. foot.		Maximum Absorption, per cent.
	Knife Edge[1] and Three-Point[2] Bearings.	Sand Bearing.[3]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8
39	3300	4710	8
42	3520	5030	8

[1] See Section 11. [2] See Section 12. [3] See Section 13.

STANDARD SPECIFICATIONS FOR FIRE TESTS OF MATERIALS AND CONSTRUCTION.

(SERIAL DESIGNATION: C 19 – 18.)[1]

Section 2 (a).—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The temperature fixed by the curve shall be deemed to be the average [true] temperature [of the furnace gases as] obtained from the readings of several thermo-couples (not less than three) symmetrically disposed and distributed [in such a manner as] to show [temperatures of the gases] *the temperature* near all parts of the sample, *said thermo-couples being enclosed in sealed porcelain tubes of $\frac{3}{4}$-in. outside diameter and $\frac{1}{8}$-in. wall thickness, the immersion of the couple in the furnace chamber to be not less than 12 in. Other types of protecting tubes or pyrometers may be used, that under test conditions give the same indications as the above standard within the limit of accuracy that applies for furnace temperature measurements.*

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. P. Miller, Secretary of Committee C-5 on Fireproofing, 100 Morningside Drive, New York City.

For greater difference of design and size the time temperature curve followed shall be modified to give an exposure equal to that obtained by using the standard pryometer and curve above described.

Section 6.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The fire test on the sample with its applied load, if any, shall be continued until failure occurs, or until it has withstood the test conditions for a period equal to [1½ times that for which classification is desired] *that herein specified in the Conditions of Acceptance for the given type of construction.*"

TABLE I.

Parts of Structure.	Type of Protection.	Size of Hose Nozzle, in.	Water Pressure at Nozzle, lb.	Time of Application, min.
Floors and Roofs	4 hour	1 1/8	50	[10] *7*
	2 "	1 1/8	50	[5] *4*
	1 "	1 1/8	50	[2.5] *2*
	1/2 "	1 1/8	30	1
	1/4 "	1 1/8	[15] *30*	1
Walls[, Columns] and Partitions	4 "	1 1/8	50	5
	2 "	1 1/8	30	3
	1 "	1 1/8	30	[2.5] *2*
	1/2 "	1 1/8	30	1
	1/4 "	1 1/8	[15] *30*	1
Columns	*4* "	*1 1/8*	*50*	*3*
	2 "	*1 1/8*	*30*	*2*
	1 "	*1 1/8*	*30*	*1 1/2*
	1/2 "	*1 1/8*	*30*	*1*
	1/4 "	*1 1/8*	*30*	*1/2*

Section 7.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"A second test with duplicate sample shall be made to determine the effect of a hose stream on a sample under fire test, the water being applied at the end of a period equal to [three-fourths] *one-half* of that for which classification is desired, but not later than one hour after the beginning of the test; except that for classification periods of one-half hour or less the fire stream test may be omitted.

Table I.—Change Table I, referred to in Section 8, to read as indicated in the accompanying Table I by the addition of the italicized word and figures and the omission of the word and figures in brackets.

Section 9.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets, changing the side heading from "Loading" to "Loading and Additional Tests":

> "For any material or construction intended to carry load other than its own weight, the full [rated safe] working load shall be applied during the entire fire test, also during the fire stream test. After completion of the fire stream test, the sample shall be subjected to [excess loading as prescribed under specifications for the different structural parts] *additional tests as herein specified in the Conditions of Acceptance for the given type of construction.*"

Add a new Section 10, under the sub-division "Conduct of Fire Tests," entitled "Time of Testing," to read as follows:

> "The material or construction shall not be tested until a large proportion of its final strength has been attained and the excess of free water has been given off. Where this cannot be attained within 40 days, artificial drying with air temperature not exceeding 100° F. shall be used."

Section 10.—Renumber the present Section 10 to Section 12.

Section 11.—Omit this section reading as follows:

> "The floor or roof may be tested as soon after construction as desired, but within 40 days. Artificial drying will be allowed if desired."

Section 12.—Transfer this section, placing it under the subdivision "Conduct of Fire Tests," renumbering it Section 11.

Section 14.—Change the side heading to read "Conditions of Acceptance."

Section 14 (a).—Change to read as follows by the omission of the words in brackets:

> "The floor or roof shall have sustained safely the full [rated safe] working load during the fire test without passage of flame for a period equal to 1¼ times that for which classification is desired."

Section 18.—Change the side heading to read "Conditions of Acceptance."

Add five new sections relating to column tests to read as follows:

> 19. *Size of Sample.*—For column tests, the length of the column exposed to fire shall approximate the clear length of the member in the structure, and for building columns shall be not less than 9 ft. The outside lateral dimensions shall be the minimum for which classification is desired. The details of construction, and exposed connections and protection, if any, shall be applied according to the methods of acceptable field practice.
>
> 20. *Loading.*—During the fire test and the fire and water test, a constant working load shall be applied to the column, calculated according to the governing design regulations. Provisions shall be made for transmitting the load to the exposed portion without unduly increasing the effective column length.

21. *Measurements.*—Measurements shall be made of the expansion or depression at the head of the column and determination of the period of expansion. Such other measurements shall be made of deformation and of temperature of the column as will give the most useful information for the given column type.

22. *Position of Nozzle.*—The distance of the nozzle from the column during the application of water shall be 20 ft., the water being applied in succession, as uniformly as possible, over the full height on three of its sides.

23. *Conditions of Acceptance.*—The test shall not be regarded as successful unless the following conditions are met:

(*a*) The column shall have sustained the full working load during the fire test for a period equal to —[1] times that for which classification is desired.

(*b*) The column shall have sustained the full working load during the fire stream test as prescribed in Sections 7 and 8, and after its completion and when cold shall sustain a total load equal to the dead load component plus twice the live load component of its design working load.

(*c*) After the fire stream test the column when dry shall withstand, under working load, a fire test of duration equal to —[1] of the period for which classification is desired, but not exceeding one hour.

D. MISCELLANEOUS MATERIALS.

STANDARD SPECIFICATIONS FOR PURITY OF RAW TUNG OIL.

(SERIAL DESIGNATION: D 12 - 16.)[2]

A revision in the form of separate specifications entitled "Specifications for Raw Tung Oil (D 12 - 22 T)[3] is intended to replace the present standard specifications.

STANDARD METHODS OF TESTING LUBRICANTS (SPECIFIC GRAVITY, FREE ACID, CARBON RESIDUE, VISCOSITY).

(SERIAL DESIGNATION: D 47 - 21.)[4]

Section 6 (*a*).—Change the third sentence to read as follows by the addition of the italicized figures:

"At the bottom of the standard oil tube is a small outlet tube through which the oil to be tested flows into a receiving flask, Fig. 3, whose capacity *at 20° C. (68 F.)* to a mark on its neck is 60 (±0.15) cc."

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[1] The quantity to be inserted in this blank space will be supplied by the committee when the information is available.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

[3] See p. 742.

[4] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Section 6 (b).—Add the following dimension to the table included in Section 6 (*b*):

"Depth of cylindrical part of container, minimum, cm..............8.8."

Add a new section to read as follows:

"The Saybolt Standard Universal Viscosimeter shall not be used for times of flow less than 32 seconds."

STANDARD METHOD OF TEST FOR QUANTITY OF CLAY AND SILT IN GRAVEL FOR HIGHWAY CONSTRUCTION.

(SERIAL DESIGNATION: D 74 - 21.)[1]

A revision in the form of a separate method of test entitled "Method of Decantation Test for Sand and Other Fine Aggregates (D 136 - 22 T)"[2] is intended to replace the present standard method.

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COAL.

(SERIAL DESIGNATION: D 22 - 21.)[3]

On page 764 of the 1921 Book of A.S.T.M. Standards, line 5, omit "No. 2," substituting in place thereof the word "a"; on page 766, line 4, omit "No. 2"; on page 769, beginning with the third line under Apparatus, change the following paragraph from its present form: namely,

"*Porcelain, Silica, or Platinum Crucibles or Capsules.*—For igniting coal with the Eschka mixture.

"No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.

"No. 1 porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coal, owing to the deeper form, than with the shallow capsules described above.

"No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the $BaSO_4$."

to read as follows:

"*Porcelain, Silica, or Platinum Crucibles or Capsules.*—Porcelain capsules, ⅞ in. deep and 1¾ in. in diameter, or porcelain crucibles of 30 cc. capacity, high

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[1] 1921 Book of A.S.T.M. Standards. Criticisms are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

[2] See p. 802.

[3] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

> or low form, or platinum crucibles of similar size are to be used for igniting coal with the Eschka mixture.
>
> "Porcelain, platinum, alundum, or silica crucibles of 10 to 15 cc. capacity, are to be used for igniting the $BaSO_4$."

On page 770, under Method, change the second sentence in the first paragraph, on Preparation of Sample and Mixture, from its present form: namely,

> "Transfer to a No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 crucible or a platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

to read as follows:

> "Transfer to a porcelain capsule, ⅞ in. deep and 1¾ in. in diameter, or a porcelain crucible of 30 cc. capacity, high or low form, or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

A revision in the form of a separate tentative method entitled "Method of Test for Fusibility of Coal Ash (D 22 - 22 T)"[1] is intended to become a part of the present standard methods.

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COKE.

(SERIAL DESIGNATION: D 37 - 21.)[2]

On page 790 of the 1921 Book of A.S.T.M. Standards, line 1, omit "No. 2"; on page 791, line 4, omit "No. 2"; on page 794, beginning with the third line under Apparatus, change the following paragraph from its present form: namely,

> "*Porcelain, Silica, or Platinum Crucibles or Capsules.*—For igniting coke with the Eschka mixture.
>
> "No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.
>
> "No. 1 porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coke owing to the deeper form, than with the shallow capsules described above.
>
> "No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the $BaSO_4$."

to read as follows:

> "*Porcelain, Silica, or Platinum Crucibles or Capsules.*—Porcelain capsules, ⅞ in. deep and 1¾ in. in diameter, or porcelain crucibles of 30 cc. capacity, high

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[1] See p. 815.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

or low form, or platinum crucibles of similar size are to be used for igniting coke with the Eschka mixture.

"Porcelain, platinum, alundum, or silica crucibles of 10 to 15 cc. capacity, are to be used for igniting the $BaSO_4$."

On page 795, under Method, change the first paragraph on Preparation of Sample and Mixture from its present form: namely,

"*Preparation of Sample and Mixture.*—Thoroughly mix on glazed paper, 1 g. of 60-mesh coke and 3 g. of Eschka mixture. Transfer to a No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 porcelain crucible or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

to read as follows:

"*Preparation of Sample and Mixture.*—Thoroughly mix on glazed paper, 1 g. of 60-mesh coke and 3 g. of Eschka mixture. Transfer to a porcelain capsule, $\frac{7}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, or a porcelain crucible of 30 cc. capacity high or low form, or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

STANDARD METHODS OF TESTING COTTON RUBBER-LINED HOSE.

(SERIAL DESIGNATION: D 15 – 15.)[1]

A revision in the form of separate methods of testing entitled "Methods of Testing Rubber Products (D 15– 22 T)"[2] are intended to replace the present standard methods.

E. MISCELLANEOUS SUBJECTS.

STANDARD DEFINITIONS AND RULES GOVERNING THE PREPARATION OF MICROGRAPHS OF METALS AND ALLOYS.

(SERIAL DESIGNATION: E 2 – 20.)[3]

A revision in the form of additional definitions of terms entitled "Tentative Definitions of Terms Relating to Metallography (E 2– 21 T)"[4] is intended to become a part of the present standard definitions.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

[2] See p. 947.

[3] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.

[4] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 829 (1921).

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